DRAFT

USDA Service Center Agencies
GPS & Digital Camera Procurement Recommendations

Supporting the National Enterprise GIS

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EXECUTIVE SUMMARY

Background

GPS and digital cameras will dramatically improve Service Center employee productivity by revolutionizing data collection methods. With GPS, field data will be collected more efficiently and with greater accuracy than with traditional methods. GPS also leverages USDA investments in GIS by providing an efficient method to import and link collected field data into existing GIS tools with minimal user intervention. Digital cameras will enable service employees to record visual information at a site and link that information to a point in a GIS spatial layer or document a compliance or crop insurance validation. The combination of GPS and digital cameras provide efficient and effective tools to collect these data digitally, referenced to specific earth coordinates and exact dates and times.

GPS will also enable the Farm Service Agencies to meet new legislated requirements especially those related to compliance. Congress has legislated fundamental changes in the way USDA does business through the Federal Crop Insurance Act (1994), the Department of Agriculture Reorganization Act of 1994, and Reform Act of 1996. Customers are demanding services that are faster, more accurate, and easier to access, and business processes that are less complicated and more responsive.

This document provides the background and recommendations for acquisition of GPS and digital cameras for the USDA Service Center Agencies (SCA's) as part of the Common Computing Environment (CCE). Key components of the CCE are Geographic Information Systems (GIS), Global Positioning System (GPS) and digital cameras.

A GPS / Digital Camera Team was established to develop requirements and recommendations for GPS and digital cameras for USDA Service Centers. This team was made up of business and technical specialist form SCA. Members of the team were selected because of their business and technical expertise with GPS and digital cameras. These team members have been involved in the use and evaluation of these technologies for several years. The following recommendations are based on their understanding of agency business processes and on the use of the technologies. Appendix 1 - USDA GPS/Digital Camera Service Center Team provides a listing of team members.

Team Recommendations for GPS Implementation

1) Develop a procurement vehicle that allows Service Center Agencies to acquire additional GPS Systems or components beyond those purchased as part of an initial procurement.
2) The GPS Systems should be shipped as a complete package from the vendor, directly to the identified locations.
3) Develop training, support, and infrastructure needed to implement GPS at the Service Center level, including:
    - As a minimum, identify and develop one key GPS leader (Tier 1) for each Agency at each Service Center.
    - At the state level, identify a State GPS Coordinator (Tier 2) for each Agency.
    - For each Agency, identify a National GPS coordinator, (Tier3).
    - Develop agency specific GPS Application manuals.
    - Develop a statewide training plan and process for each agency and provide training to coincide with the delivery of the GPS equipment.

4) Develop and deploy the ArcView/GPS interface to Service Centers in conjunction with the deployment of GPS Systems.

5) Establish two standard GPS system configurations. Configuration 1 is the HIGH option and is Real Time GPS/NDGPS System. Configuration 2 is the LOW option with standard GPS capability. Both configurations have a backpack and antenna and have a common GPS receiver. Configuration 2 does not have a NDGPS receiver.

The following recommendations represent the total GPS system need and are basically listed in priority order. Initial procurement should address these needs in priority order as far as funding allows.

6) Acquire a minimum of one Real Time GPS/NDGPS System (Configuration 1) each for FSA and NRCS for all Service Center locations where there is NDGPS coverage.

FSA	Service Centers Offices	2381
NRCS	Service Center Offices	2527
RT GPS/NDGPS System (Config.1)	**TOTAL**	**4908**

7) Acquire an additional Real Time GPS/NDGPS System (Configuration 1) for each "larger" FSA Service Center offices (field offices with 5 or greater FSA Service Center staff).

FSA	Service Centers Offices	1360
RT GPS/NDGPS System (Config. 1)	**TOTAL**	**1360**

8) Acquire additional Real Time GPS/DGPS System (Configuration 1) for each Service Center Agency's Sate Office and other special offices.

FSA	State Office	52
	Program delivery Point	7
NRCS	State Offices	53
	Area Offices	96
	Program Delivery Point	136
	Soil Survey Offices	774
	Water Quality Offices	8
	Watershed Project Offices	34
	Plant Material Centers	25
RD	State Offices	48
RT GPS/NDGPS System (Config. 1)	**TOTAL**	**1233**

9) Acquire GPS Systems (Configuration 2) as needed for each agency.

FSA	State Office	52
NRCS	Service Centers	4132
	State Offices	53
	Water Quality Offices	16
	RC&D	321
RD	Area Offices	141
	Service Centers	657
	Program Delivery Point	9
GPS System (Config. 2)	**TOTAL**	**5381**

Team Recommendation for Digital Camera Implementation

1) Establish one standard camera configuration.

2) Acquire Digital cameras with Compact Flash Card readers for Service Centers, State offices, and other special offices.

FSA	Service Centers	2381
	State Office	52
	Program delivery Point	7
NRCS	Service Centers	2527
	State Offices	53
	Area Offices	96
	Program Delivery Point	136
	Soil Survey Offices	287
	Water Quality Offices	8
	Watershed Project Offices	34
	Plant Material Centers	25
	River Basin Project Office	1
	RC & D Offices	705
	SNOTEL Office	1
	Grazing Lands Technology Insti.	6
RD	Service Centers	657
	State Offices	48
	Area Offices	141
	Program Delivery Point	9
Digital Cameras & Flash Card Readers		**TOTAL 7174**

THE APPLICATIONS AND BENEFITS OF USING GPS

Benefits to NRCS

The NRCS has been actively using GPS for more than 6 years. With almost 1000 GPS receivers there are almost as many individual applications as there are receivers. The predominate application of GPS in NRCS, has been collecting field data for NRCS programs such as: Conservation Reserve Program (CRP), Natural Resources Inventory Program (NRI), Emergency Watershed Program (EWP), Environmental Quality Incentives Program (EQIP), Forestry Incentives Program (FIP), and Wildlife Habitat Incentives Program (WHIP). Another major application of GPS in NRCS has been the use of GPS for conservation planning and technical assistance.

One of the largest potential benefits for timesavings and providing better customer service is the use of GPS for conservation practice certification. Recently, Texas NRCS undertook a major study to determine just how useful GPS could be for certifying conservation practices. After an extensive study of traditional methods and techniques compared to GPS methods and techniques, they concluded that GPS can provide more accurate results and better products and assistance to the customer is less time than traditional methods of certifying conservation practices.

Efficiency and Customer Service **From the Texas NRCS Report**

The Customer Service Toolkit and GPS technology are revolutionizing the way we provide services to our customers. This technology will provide significant statewide time and dollar savings (see Table 1). Listed below are reasons why this technology should be implemented statewide as soon as possible.

- GPS measurements are significantly more accurate than traditional methods of measurement. This improved accuracy will reduce or eliminate over or under payments to producers.
- Using a GPS system, one person is capable of conservation practice measurements that previously required two or three person teams. Traditional measurement methods that required a half-day can be reduced to an hour or less and a full day job can be done in 1 to 2 hours.
- GPS allows for field calculation of areas, lengths, and locations that can be readily provided to producers and contractors.
- Field personnel can design conservation practices (i.e. brush management patterns) in the office using ArcView and then upload this information to the GPS. The GPS is then used to layout the conservation practice in the field by following the coordinates that were uploaded.
- GPS is a mobile tool that allows planners to provide cooperators with real time, on-site information to help in decision making, which previously would have required return visits
- The moving map display on the GPS receiver can be used as a navigational aid to save time in the field.
- Accurate positions of physical features (i.e. pipelines, fences, wells, etc) can be marked with a GPS system in a relatively short period of time as compared to previous methods.
- Information collected with GPS is already in electronic format and does not require any conversion from hardcopy documents.
- GPS allows for the development of geospatial data layers in the field (i.e.CLU layer) that can be shared with producers and other agencies.
- When GPS is used in combination with ArcView, field employees can provide a high quality product (i.e. maps, etc.) to customers.
  GPS aids in conservation planning by providing on-site information (i.e. drainage areas, field and pasture sizes, and proximity to other structures) when planning conservation alternatives.

Annual Benefit to NRCS

Maybe the most surprising finding in the Texas NRCS report, is the amount of time saved using GPS for conservation practice layout and certification. Based on 135 practices applied annually by one resource team the timesavings accounted for 305 hours. For the state of Texas, with 95 resource teams, the potential annual timesavings are 28,975 hours. From a taxpayer viewpoint, that is over $527,000.00 in annual salaries.

The real "pot of gold" here, is the time savings and the better products and services that can be provided to the customer. Texas accounts for 8.3% of the Service Centers in the U.S. Annual savings of 28,975 hours on 8.3% of the country, would mean that NRCS could expect to save 349,000 hours annually. That's over 175 staff years.

Testimonies from the Field

GPS Saves Time and Increases Accuracy of Practice Certification

By Chance Walker, Rangeland Management Specialist, NRCS, Baird, Texas

When we received our first GPS unit, one of the first things that we wanted to due was to compare the GPS measurements to something that we had previously measured using our standard measuring techniques. We picked a pasture where we had just completed a brush management practice (aerial spray).

We used our standard technique for measuring this area which was to take an aerial photo to the field, draw the area off on the map, go back to the office, make an overlay map of the area and use a planimeter to measure the area. It took approximately an hour or so to draw the area off on the map in the field and about 30 minutes or so to make an overlay map and planimeter this area in the office. The approximate area of this brush management area was 225 acres.

We went back to this same area armed with a GPS and a laptop with ArcView GIS loaded on it. We measured the same area we had measured with our standard technique. It took 14 minutes to drive around the perimeter of the area where the brush management had been completed, collecting GPS data. It took 1 minute to hook the GPS up to the laptop and download the collected data. It then took about 1 minute to import this information into ArcView and calculate an area.

To our amazement, the GPS and ArcView calculated approximately 240 acres; about 15 acres more than we had previously measured! We compared the two measurements and discovered that GPS put us exactly on the perimeter of the area measured, and the hand drawn area was not exactly where it should have been. When conducting area measurements in the field by hand, it is sometimes hard to tell exactly where you are on the ground in relation to a hard copy map. You have to use your best judgement on where to delineate the boundaries of a practice.

In contrast, the GPS puts the line exactly where it should be and does not introduce any human error or judgement. The bottom line is, we were able to measure the area in a 6th of the time and dramatically increase our accuracy with GPS as compared to our old way of measuring this type of practice. From that point on, we were sold on GPS.

An Update from the Field - Using GPS

By Ricky Linex, Rangeland Management Specialist, NRCS, Abilene, Texas

Since the Abilene Pilot Site received that green PLGR we have been excited about the use of GPS in the field. We are still using the PLGR three days a week, every week to measure brush control areas predominately in Nolan County but also in Taylor County.

Through some priority area funds in Nolan County, the Rolling Plains RC&D office purchased a Garmin GPS III Plus with the NDGPS system and MapSource CD. We are using this 2-3 days a week for a variety of purposes, among which in the past week:

- In support of CRP plans we have measured and staked in the field Annual Food Plot areas, staked 51% re-establishment areas on expired CRP contracts that are going back into CRP, and measured areas for the 5% shrubs that are planted for wildlife food and cover. Being able to measure 51% of the area of a CRP field will save many hours for field office employees who are laying out these areas. In support of EQIP planning we have laid off brush control areas in ArcView, uploaded these areas into the Garmin unit, went to the field and flagged the areas following the bread crumb trail the GPS shows on the screen.
- In support of CCRP we are using the Garmin to assist in determining boundaries for enrollment in Continuous CRP.
- In support of basic conservation technical assistance with no cost shares involved, we met with landowner in the office and planned a brush control pattern in ArcView involving 10 separate areas totaling 39 acres to be tree-dozed and seeded on his 112 acre ranch. ArcView was used to layer the CIR photography with the soils map and digital raster graphs to choose the best areas for treatment. We were able to choose the treatment areas based on using the best soils and areas with the most gentle terrain to lay in brush clearing areas that will have brush piles raked, burned and reseeded to beneficial grasses and forbs for wildlife. These 10 areas were uploaded to the Garmin, and laid out on the ranch in about 3 hours by one employee. This is an improvement in time spent laying out the practice and in the accuracy of the areas flagged. Once in the field only two areas had to have any adjustment made to their boundaries and this was caused by small washes not showing on the map. Incidentally, the Garmin will even give you directions on how to get to the area uploaded, and the detail available with the MapSource CD even showed the location of a ranch road on the ranch that divided two brush control areas. An important consideration I hope you will share with your partners is the need for the software to interface with ArcView.

Any GPS unit will record waypoints but unless you can download or upload these waypoints into ArcView it will not be of any use at the field level. The GIS Technology group from Texas has worked hard to make GPS and ArcView a compatible working tool. The Garmin GPS III Plus works with our ArcView program because the software works. I want you to know that I use a Garmin GPS weekly and I know it will be a great time saver for employees if a nationwide purchase is made. The real key is for the Software to be compatible with whatever GPS units are purchased. We've come a long way since the green PLGR and I hope every office will soon have these tools that will help us do a better job of conservation planning and application.

GPS Saves Time for Crop Appraisal Certification

By Levi Garlick, County Executive Director, FSA, LaGrange, Texas

One June 29, 2000, FSA and NRCS personnel from Fayette County, Texas measured three fields for acreage determination for crop appraisal. These were irregularly shaped fields and were parts of larger fields. Two methods were used: 1) FSA standard field measurement and 2) GPS unit and GIS software by NRCS personnel.

The FSA standard field measurement consisted of using a measuring wheel (chains) and aerial photo. The photos were used to mark boundaries and field measurements. Points of reference were made for accuracy. Each point on the field had to be referenced by 2 or 3 reference points. Upon completion of the field visit, the map was then taken to the service center for measurement using the numonics electronic planimeter. From start to finish to measure these three fields took eight hours.

The second method of measurement involved the use of GPS equipment and a laptop computer with digital orthoimagery and supporting software. Measurement with the GPS unit involved locating waypoints for the boundaries of the three fields, downloading this data into a laptop (in the field), editing waypoints, and producing polygons using GIS software. Acreage calculations for each field were made using GIS software. Total time start to finish for plotting the three fields, measuring, and validating the field boundaries with digital orthoimagery was less than one hour.

The acreage calculations using GPS/GIS equipment was within one-tenth of an acre of that measured using FSA standard method.

INTRODUCTION

The U.S. Department of Agriculture (USDA) Service Center concept is a cornerstone of reorganization efforts begun under the Reorganization Act of 1994. The National Performance Review recommendations for budget reduction and downsizing will require USDA employees to streamline business processes while ensuring timely program delivery and customer satisfaction.

USDA's Service Center Agencies: Farm Service Agency (FSA), Natural Resources Conservation Service (NRCS), Rural Development (RD), and Risk Management Agency (RMA), have been challenged to provide high-quality "one-stop" service to customers of all agencies. The Service Center "one-stop" service concept is based on coordination and cooperation among the partner agencies. To be successful, this coordination and cooperation must extend to the agencies information systems that support the delivery of USDA programs and services. An important goal of the Service Center concept is providing services wherever customers are located. This will require mobility of delivery of services, and integrated systems that allow customer data to be accessed and displayed at any office. Therefore, the partner agencies must have a common vision and approach for the integration, development, and maintenance of Service Center information systems.

Most of USDA's business data is geospatial in nature, or referenced to geographical locations. The ability to manage this data efficiently and effectively as we move toward becoming "one-stop" shopping service centers is essential. For this data to be managed efficiently and effectively, the Geographic Information System (GIS) and geospatial information need to be available to every level of USDA. Of all of the technologies being introduced under the Service Center Initiative (SCI), GIS may have the greatest and longest lasting impact on the products and services provided to customers. The Enterprise GIS Team was formed under USDA's Common Computing Environment (CCE) initiative. Team members were selected from all Service Center Agencies. [1]

In the future, USDA products and services will be linked spatially to digital maps. The client will associate USDA programs and business with the farms and fields to which they apply. The ability to effectively provide service is dependent on the capability to quickly to the public.

PURPOSE

The purpose of this report is to identify USDA Service Center GPS and digital camera requirements and to recommend a GPS & digital camera solution for USDA Service Centers. This report is in three parts:

Part 1 - GPS

- Describes Global Positioning System (GPS) and recent changes and opportunities.
- Describes Nationwide Differential Global Positioning System (NDGPS).
- Identifies the benefits of using GPS & NDGPS

Part 2 - Digital Cameras

- Describe the capabilities and benefits of Digital Cameras.
- Identifies Digital Cameras requirements.

Part 3 - Recommendations

- Provide recommendations for a GPS and digital cameras for USDA Service Centers.

[1] USDA Service Center Agencies Recommendation for National Enterprise Geographic Information System (GIS) Solution, September 21, 1999

TEAM TASK

To support USDA Service Center field data collection requirements for GIS, the GPS / Digital Camera Service Center Initiative Team was formed with technical specialists from all the Service Center Agencies. In addition a Service Center representative from each Service Center Agency participated on the team. The team was tasked by the USDA CCE Team Leader, Dennis Lytle, to develop the requirements and recommendations for GPS and Digital Cameras for USDA Service Centers. Members of the team were selected because of their business and technical expertise with GPS and digital cameras. These team members have been involved in the use and evaluation of these technologies for several years. The following recommendations are based on their understanding of agency business processes and on the use of the technologies. Appendix 1 - USDA GPS/Digital Camera Service Center Team provides a listing of team members.

General Considerations in Formulating Recommendations

The team considered the following general factors when they formulated the recommendations:

Commercial -of-the-shelf (COTS) – Whenever possible Identify COTS products that meet Service Center Agency GPS and digital camera requirements in order to minimize government development of products that exist in the open market.

User Friendliness / Ease of Use - To fully realize the potential of field data collection tools like GPS and digital cameras, they must be user friendly and ease to use.

Out of the Box Functionality - The recommended GPS / digital camera solution must provide complete functionality. It is important to deliver a complete system to the Service Centers, insuring uniform capability.

Training Cost and Access - Choosing products that can be used with minimal training and still expect to meet the User's requirements. Vendors should have manuals that are clear and understandable. Procedures and techniques for successfully using the equipment should be well documented.

Technical Support - Vendors should have technical support available by phone or Internet as needed.

Integrated solution – The recommended GPS and digital camera solutions must be complete and totally interactive with the Common Computing Environment.

Interface requirements - All interface and communication properties of the recommended system must be complete and allow maximum flexibility for the user to configure their equipment as needed.

PART 1 – USDA SERVICE CENTER BUSINESS REQUIREMENTS

Global positioning technology is relatively new technology to USDA; therefore, policies, standards and business practices have not yet been adjusted in light of this new technology. The GPS/Camera Team worked with business specialists to determine what would be appropriate GPS accuracy requirement based on current policy, standards, and acceptable business practices. The following matrices detail the business practices analyzed and the corresponding GPS accuracy requirements for each Service Center Agency.

The business requirements DO NOT include GPS requirements for survey grade GPS units. Survey Grade units are expensive and would not generally be used by field office personnel; however, it is recognized that there will be a need for a limited number of these types of units. Procurement of survey grade units should be handled on a case by case basis. They should be approved and funded by the appropriate Service Center Agency as needed.

Two business requirements are not mentioned but are assumed throughout: ease of use and ease of importing collect data into Service Center GIS tools.

Ease of Use

A GPS system must be simple and easy to use so that field personnel will assimilate and incorporate GPS technology into their everyday business practices,. This means that the GPS receiver must have an intuitive interface, manuals that are easy to understand, and peripherals that are simple to connect (e.g. NGDPS receiver, external antennae etc.). This business requirement dictates that custom made, color coded, cabling be constructed to connect all the various GPS system components. These components include antennae, NGDPS reciever, power supply, GPS receiver, and serial cable to the computer etc. The recommended GPS systems are specified in Appendix ???? and the cable diagrams are in Appendix ??????

Ease of Importing GPS Data

GPS data that is collected in the field must be easily imported into Service Center GIS tools in order to fully leverage the usefulness of a GPS system and the GIS tools. No GPS unit provides this capability out of the box but should it provide the communication access and protocols that would allow third party software developers to build an easy to user interface. Currently there is software freely available that provides the basic GIS import functionality to Service Center GIS tools. This software will work in the short term; however, a more robust and functional interface is needed for the long term. The fully functional GIS interface to the GPS system is recommended to be a separate project with its own funding resources.

Business Requirements Summary

Looking across all the Service Center agencies and business processes, the lowest common denominator accuracy requirement for a GPS system is a 5 meter or less positional accuracy. This means that the HIGH end GPS system (Cnfiguration 1) must consistently deliver this level accuracy. This requirement means that, where a signal is available, an NDGPS receiver must be utilized for certain business practices. Currently, most of the United States has NDGPS signal coverage. It also recognized that a sub 5 meter accuracy is not always necessary. Therefore, a LOW end configuration is recommended for these situations. The LOW end configuration should give sub 30???? meter accuracy and will cost significantly less.

NRCS BUSINESS Requirement Matrix for GPS Units

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
Identifying Food, Feed & Facilities Structures	Emergency Preparedness	R		R	*Physical location (address-search by zip code), Longitude and Latitude*	Within 5 meters	1-DP		I
Identify scope and effect of weather events	NAP, Disaster, Price Support, ECP, RMA/ARPA Compliance, Farm Loan Program, STORM	R	R	R		Within 5 meters	1-RMA 1-NAP, (Rev 1) 1-DAP 3-DAP 1-LP		F
Common Land Unit (CLU) Maintenance	All programs	R		R	*Standard is 21ft for minimum width for internal deductions. Smaller authorized deviations include 6 ft minimum width for Oregon, 2.64 ft minimum width for tobacco in Tennessee. Minimum size deviations include .2 (2/10ths) of an acre for North Dakota deduction credit.*[2]	Within 5 meters	2-CP Exhibit 20, 8-CM See 2-CP, Exhibit 20 for Deviations from Prescribed Standards	1-5 meters	F[3]
Data Collection for Appeals	All	R	R	R	Varies by program and by data required	Based on individual standards/ recommendations established for each program	Program References		F

[2] Acreage not devoted to a crop being measured must be deducted from the gross acreage. The acreage to be deducted can be measured by ground or aerial methods, or calculated by applying standard deduction percentage to the gross acreage.

[3] The frequency of GPS support of CLU maintenance depends on service center access to GIS and GPS units. It will be frequent when both are available to service centers.

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
Data Collection for Identifying Tribal Areas, (Acres) Reservations	American Indian Livestock Feed Program			R			7CFR: 1439.900-911		I
Delineation of Conservation Easements	Conservation Contracts and Conservation Easements on Inventory Property	R	R	R	Recordable under local jurisdiction. (This is a variable and qualitative requirement)	Positions within 5meters Areas within the larger of 5% or 1 acre up to a maximum of 50 acres	7 CFR : 1940-G	1-5 meters would be sufficient for most cases.	Varies by State
Navigation Capability; both upload and download capability required.	Conservation Compliance – Identification of converted wetlands boundaries	R		R	As required in 2-CP for measurement services	Within 5 meters	6-CP 2-CP	5-15 meters except for tobacco (from one to 5 meters to survey grade – see below.)	Varies by State
	Farm Credit Programs – Chattel Security	R					7 CFR : 1943-A 1941-A 1945-D 1962-A		F
	Infectious Disease Control (e.g., Foot & Mouth Disease); Bio-terrorism	R		R					I
Point Location	Environmental Assessments	R		R	Not available –currently information collection	Within 5 meters	7CFR 1940-G 1436		F

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
Point Location	Farm Credit Programs-Structure Identification	R			Not available –currently information collection		7CFR: 1924-B		F
	Farm Stored Facility Loan Program	R				Within 5 meters	1-FSFL		F
Point Location	Marketing Assistance Loans, Commodity Loans and LDPs	R				Within 5 meters	8-LP		F
	AMTA, NAP, Disaster Appraisals	R					2-NAP		F
Field Measurement[4]	Marketing Assistance Loans and LDPs			R	Larger of 1 acre or 5% of reported acreage not to exceed 50 acres.	Within 5 meters	2-CP	5-15 meters	F
	Conservation Program Enrollment and Monitoring	R	N/A	R			2-CP		F
	Peanuts	R	N/A	R	Larger of 1 acre or 5% of reported acreage. Not to exceed 10 acres for peanuts		4-CP (Rev 4) Para 22A 2-CP	5-15 meters	F
	AMTA	R	N/A	R	Larger of 1 acre or 5% of reported acreage. Not to exceed 10 acres for peanuts, 50 acres for other crops		4-CP (Rev 4) Para 22A 2-CP	5-15 meters	F

[4] Acreage not devoted to a crop being measured must be deducted from the gross acreage. The acreage to be deducted can be measured by ground or aerial methods or calculated by applying a standard deduction percentage to the gross acreage. 2-CP, exhibit 20 provides authorized deviations from prescribed standards.

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
Field Measurement, Continued	NAP	R		R	5%	Within 5 meters	4-CP (Rev 4) Para 124	5-15 meters Fields of around an acre would need 1-5 meter accuracy.	F
	Tobacco under marketing quota except flue-cured	R		R	Larger of .1 (1/10) of acre or 5%		4-CP (Rev 4) Para 22E 2-CP(Rev 15) Par 354 J	1-5 meters	F
	Tobacco acreage allotment marketing quotas except burley, dark air-cured and fire-cured	R		R	Larger of .1 (1/10) of acre or 2%		4-CP (Rev 4) Para 22C 2-CP(Rev 15) Par 354 H	1-5 meters	F
	Tobacco-dark air cured and fire cured	R		R	.01 to .99 - .01 to 1.49 - .02 1.5 to 1.99 - .03 to 2.49 - .04 2.5 to 2.99 -.05 to 3.49 - .06 3.5 to 3.99 - .07 to 4.49 - .08 4.5 and up - .09		4-CP Rev 4) Par 22D 2-CP(Rev 15) Par 354 G	Survey grade GPS Sub-meter accuracy	F
Measurement Services - Stake & Referencing	Measurement Services	R	R	R	Standard for redetermination is the larger of 3% or .5 (1/2) acre. Smaller approved deviations include .1 ($1/10^{th}$) of acre for tobacco; larger of .1 ($1/10^{th}$) or 10% for areas smaller than 5 acres in Virginia.		2-CP Rev 15 Para 397F, Ex 20	1-5 meters	F
Measurement Services – Area			R	R			2-CP Rev 15 Para 397F, Ex 20	1-5 meters	F

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
Distance Measuring	Conservation Program Enrollment and Monitoring		R		N/A	Larger of 3% or 3 feet			F
Required Accuracy Range for GPS Units								1-5 meter	

Additional Functional Requirements:

- User attribution capability of a minimum of five (5) characters.

FSA BUSINESS Requirement Matrix for GPS Units

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
Identifying Food, Feed & Facilities Structures	Emergency Preparedness	R		R	*Physical location (address-search by zip code), Longitude and Latitude*	Within 5 meters	1-DP		I
Identify scope and effect of weather events	NAP, Disaster, Price Support, ECP, RMA/ARPA Compliance, Farm Loan Program, STORM	R	R	R		Within 5 meters	1-RMA 1-NAP, (Rev 1) 1-DAP 3-DAP 1-LP		F
Common Land Unit (CLU) Maintenance	All programs	R		R	*Standard is 21ft for minimum width for internal deductions. Smaller authorized deviations include 6 ft minimum width for Oregon, 2.64 ft minimum width for tobacco in Tennessee. Minimum size deviations include .2 (2/10ths) of an acre for North Dakota deduction credit.*[5]	Within 5 meters	2-CP Exhibit 20, 8-CM See 2-CP, Exhibit 20 for Deviations from Prescribed Standards	1-5 meters	F[6]

[5] Acreage not devoted to a crop being measured must be deducted from the gross acreage. The acreage to be deducted can be measured by ground or aerial methods, or calculated by applying standard deduction percentage to the gross acreage.

[6] The frequency of GPS support of CLU maintenance depends on service center access to GIS and GPS units. It will be frequent when both are available to service centers.

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
Data Collection for Appeals	All	R	R	R	Varies by program and by data required	Based on individual standards/ recommendations established for each program	Program References		F
Data Collection for Identifying Tribal Areas, (Acres) Reservations	American Indian Livestock Feed Program			R			7CFR: 1439.900-911		I
Delineation of Conservation Easements	Conservation Contracts and Conservation Easements on Inventory Property	R	R	R	Recordable under local jurisdiction. (This is a variable and qualitative requirement)	Positions within 5meters Areas within the larger of 5% or 1 acre up to a maximum of 50 acres	7 CFR : 1940-G	1-5 meters would be sufficient for most cases.	Varies by State
Navigation Capability; both upload and download capability required.	Conservation Compliance – Identification of converted wetlands boundaries	R		R	As required in 2-CP for measurement services	Within 5 meters	6-CP 2-CP	5-15 meters except for tobacco (from one to 5 meters to survey grade – see below.)	Varies by State

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
	Farm Credit Programs – Chattel Security	R					7 CFR : 1943-A 1941-A 1945-D 1962-A		F
	Infectious Disease Control (e.g., Foot & Mouth Disease); Bio-terrorism	R		R					I
Point Location	Environmental Assessments	R		R	Not available – currently information collection	Within 5 meters	7CFR 1940-G 1436		F
Point Location	Farm Credit Programs-Structure Identification	R			Not available – currently information collection		7CFR: 1924-B		F
	Farm Stored Facility Loan Program	R				Within 5 meters	1-FSFL		F
Point Location	Marketing Assistance Loans, Commodity Loans and LDPs	R				Within 5 meters	8-LP		F
	AMTA, NAP, Disaster Appraisals	R					2-NAP		F
Field Measurement [7]	Marketing Assistance Loans and LDPs			R	Larger of 1 acre or 5% of reported acreage not to exceed 50 acres.	Within 5 meters	2-CP	5-15 meters	F
	Conservation Program Enrollment and Monitoring	R	N/A	R			2-CP		F

[7] Acreage not devoted to a crop being measured must be deducted from the gross acreage. The acreage to be deducted can be measured by ground or aerial methods or calculated by applying a standard deduction percentage to the gross acreage. 2-CP, exhibit 20 provides authorized deviations from prescribed standards.

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
	Peanuts	R	N/A	R	Larger of 1 acre or 5% of reported acreage. Not to exceed 10 acres for peanuts		4-CP (Rev 4) Para 22A 2-CP	5-15 meters	F
	AMTA	R	N/A	R	Larger of 1 acre or 5% of reported acreage. Not to exceed 10 acres for peanuts, 50 acres for other crops		4-CP (Rev 4) Para 22A 2-CP	5-15 meters	F
Field Measurement , Continued	NAP	R		R	5%	Within 5 meters	4-CP (Rev 4) Para 124	5-15 meters Fields of around an acre would need 1-5 meter accuracy.	F
	Tobacco under marketing quota except flue-cured	R		R	Larger of .1 (1/10) of acre or 5%		4-CP (Rev 4) Para 22E 2-CP(Rev 15) Par 354 J	1-5 meters	F
	Tobacco acreage allotment marketing quotas except burley, dark air-cured and fire-cured	R		R	Larger of .1 (1/10) of acre or 2%		4-CP (Rev 4) Para 22C 2-CP(Rev 15) Par 354 H	1-5 meters	F

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
	Tobacco-dark air cured and fire cured	R		R	.01 to .99 - .01 to 1.49 - .02 1.5 to 1.99 - .03 to 2.49 - .04 2.5 to 2.99 -.05 to 3.49 - .06 3.5 to 3.99 - .07 to 4.49 - .08 4.5 and up - .09		4-CP Rev 4) Par 22D 2-CP(Rev 15) Par 354 G	Survey grade GPS Sub-meter accuracy	F
Measurement Services - Stake & Referencing	Measurement Services	R	R	R	Standard for redetermination is the larger of 3% or .5 (1/2) acre. Smaller approved deviations include .1 (1/10th) of acre for tobacco; larger of .1 (1/10th) or 10% for areas smaller than 5 acres in Virginia.		2-CP Rev 15 Para 397F, Ex 20	1-5 meters	F
Measurement Services – Area			R	R			2-CP Rev 15 Para 397F, Ex 20	1-5 meters	F
Distance Measuring	Conservation Program Enrollment and Monitoring		R		N/A	Larger of 3% or 3 feet			F
Required Accuracy Range for GPS Units								1-5 meter	

Additional Functional Requirements:

- User attribution capability of a minimum of five (5) characters.

RD BUSINESS Requirement Matrix for GPS Units

Business Process Improved	Programs Supported	Data Collection Requirement			Program Accuracy	Standard RECOMMENDED	Handbook or Technical Reference	GPS Accuracy Range Based on TX Test Info.	Frequency F-Frequent I-Infrequent
		Position Optional (O) or Required (R)	Length (O/R)	Area (O/R)					
Environmental review screening ❑ Floodplains ❑ Wetlands ❑ Hazardous waste sites ❑ Other concerns	All programs	O			Not available – currently information on hard-copy maps	Within 10 meters	7CFR 1794 7CFR 1940-G		F
Program management ❑ GPRA impacts ❑ Policy evaluation ❑ Decision support	All programs	O			Not available	Within 10 meters			F
Facility location relationships ❑ Income levels ❑ Unemployment ❑ Target areas ❑ Demographics ❑ Service areas ❑ Similar characteristics	All programs	O			Not available – currently using ZIP centroids, other problem estimated points	Within 10 meters			F

Additional Functional Requirements:

- User attribution capability of a minimum of five (5) characters.

NRCS Requirement Matrix for Digital Cameras

Business Process Improved	Programs Supported	GPS Watermark Desired Yes or No	Purpose of Data Collection		Handbook or Tech. Reference
			Documentation	Evidentiary (Real Time)	
Identifying Food, Feed & Facilities	Emergency Preparedness	Y	Y	(B)eneficial	1-DP
Information Collection	Infectious Disease Control (e.g., Foot/Mouth Disease) and Bio-terrorism attack	Y	Y	B	
Identify scope and effect of weather events, natural disasters	NAP, Disaster, Price Support, ECP, RMA/ARPA Compliance, Farm Loan Program, STORM, EWP	Y	Y	B	4-RM, 1-DAP, 3-DAP, 1-NAP (Rev. 1), EWP Handbook
Data Collection for Appeals	All	Y	Y	B	Program References
Delineation/Monitoring of Conservation Easement	Conservation Contracts & Conservation Easement on Inventory Property	Y	Y	B	7 CFR 1940-G
Environmental Assessments	Farm Loan Programs Farm Stored Facility Loans	Y	Y		7CFR 1940-G 1436
Spot Check Commodity Quantity/ Quality	Commodity Loan Program	Y	Y	B	8-LP
Spot Check Crop or Crop Conditions	AMTA, NAP, Tobacco, Peanuts, Disaster, RMA Compliance,	Y	Y	B	4-CP, 2-CP
Spot Check on HELC/WC	AMTA, NAP, Tobacco, Peanuts, Disaster	Y	Y	B	4-CP, 2-CP
Security Visit for Chattel/Real Property/Crop/Livestock	Farm Loan Program	Real Property Y Crop Y	Y		7CFR: 1965-A 1955-B
Inventory Property- Maintenance & Security	Farm Loan Program	Y	Y	B	1-FLP 7CFR: 1955-B 1965-A
Inventory Property – Bankruptcy/Foreclosures	Farm Loan Program	Y	Y	B	7CFR 1951-S
Program Monitoring	Conservation Programs	Y	Y	B	2-CP
	AMTA	Y	Y		
Collection of Information for Program Decision Making Purposes	CRP Haying & Grazing, ECP, Disaster Declaration, Flash Reports, DAR,	Y	Y	B	1947
Appraisals	Farm Loan Program, NAP, Disaster, RMA/ARPA Compliance	Y	Y	Y	1922-C

Business Process Improved	Programs Supported	GPS Watermark Desired Yes or No	Purpose of Data Collection		Handbook or Tech. Reference
			Documentation	Evidentiary (Real Time)	
News & Publications	Administrative & Program	N	Y	N	
Inter/Intra-office and Inter/Intra-agency Communication	All programs	Y	Y		
Education and Outreach	All programs	N	Y	N	
Document Resource Conditions (Rangeland Inventories, Existing Conditions, Structures)	All programs	Y	Y	N	NPPH, FOTG
Ecological Site Descriptions	Conservation Programs	Y	Y	N	National Grazinglands Handbook
Soil Survey	Soil Survey Program	N	Y	N	National Soils Handbook
Document Applied Conservation Practices	Conservation Programs	N	Y	N	NPPH, FOTG

FSA Requirement Matrix for Digital Cameras

Business Process Improved	Programs Supported	GPS Watermark Desired Yes or No	Purpose of Data Collection		Handbook or Tech. Reference
			Documentation	Evidentiary (Real Time)	
Identifying Food, Feed & Facilities	Emergency Preparedness	Y	Y	(B)eneficial	**1-DP**
Information Collection	Infectious Disease Control (e.g., Foot/Mouth Disease) and Bio-terrorism attack	Y	Y	B	
Identify scope and effect of weather events	NAP, Disaster, Price Support, ECP, RMA/ARPA Compliance, Farm Loan Program, STORM	Y	Y	B	4-RM, 1-DAP, 3-DAP, 1-NAP (Rev. 1)
Data Collection for Appeals	All	Y	Y	B	Program References
Delineation/Monitoring of Conservation Easement	Conservation Contracts & Conservation Easement on Inventory Property	Y	Y	B	7 CFR 1940-G
Environmental Assessments	Farm Loan Programs Farm Stored Facility Loans	Y	Y		7CFR 1940-G 1436
Spot Check Commodity Quantity/ Quality	Commodity Loan Program	Y	Y	B	8-LP
Spot Check Crop or Crop Conditions	AMTA, NAP, Tobacco, Peanuts, Disaster, RMA Compliance,	Y	Y	B	4-CP, 2-CP
Spot Check on HELC/WC	AMTA, NAP, Tobacco, Peanuts, Disaster	Y	Y	B	4-CP, 2-CP
Security Visit for Chattel/Real Property/Crop/Livestock	Farm Loan Program	Real Property Y Crop Y	Y		7CFR: 1965-A 1955-B
Inventory Property- Maintenance & Security	Farm Loan Program	Y	Y	B	**1-FLP** 7CFR: 1955-B 1965-A
Inventory Property – Bankruptcy/Foreclosures	Farm Loan Program	Y	Y	B	7CFR 1951-S
Program Monitoring	Conservation Programs	Y	Y	B	2-CP
	AMTA	Y	Y		
Collection of Information for Program Decision Making Purposes	CRP Haying & Grazing, ECP, Disaster Declaration, Flash Reports, DAR,	Y	Y	B	1947
Appraisals	Farm Loan Program, NAP, Disaster, RMA/ARPA Compliance	Y	Y	Y	1922-C

Business Process Improved	Programs Supported	GPS Watermark Desired Yes or No	Purpose of Data Collection		Handbook or Tech. Reference
			Documentation	Evidentiary (Real Time)	
News & Publications	Administrative & Program	N	Y	N	
Inter/Intra-office and Inter/Intra-agency Communication	All programs	Y	Y		
Education and Outreach	All programs	N	Y	N	

RD Requirement Matrix for Digital Cameras

Business Process Improved	Programs Supported	GPS Watermark Desired Yes or No	Purpose of Data Collection		Handbook or Tech. Reference
			Documentation	Evidentiary (Real Time)	
Environmental Assessments	All programs	N	Y		7CFR 1794 7CFR 1940-G
Construction inspections & troubleshooting	All programs	N	Y		
Marketing Inventory Property	Housing Programs	N	Y		
Inventory Property- Maintenance & Security	Housing Programs	N	Y		
Security Inspections	All programs	N	Y		
Appraisals	All programs	Maybe	Y		
News & Publications	Administrative & All Programs	N	Y		
Inter/Intra-office and Inter/Intra-agency Communication	All programs	N	Y		
Training and Outreach	All programs	N	Y		

PART 2 - GPS

The NAVSTAR Global Positioning System (GPS) was developed and initiated by the Department of Defense in 1993 for the purpose of providing the U. S. Military with navigation and positioning capability anywhere on earth, anytime, under any and all conditions.

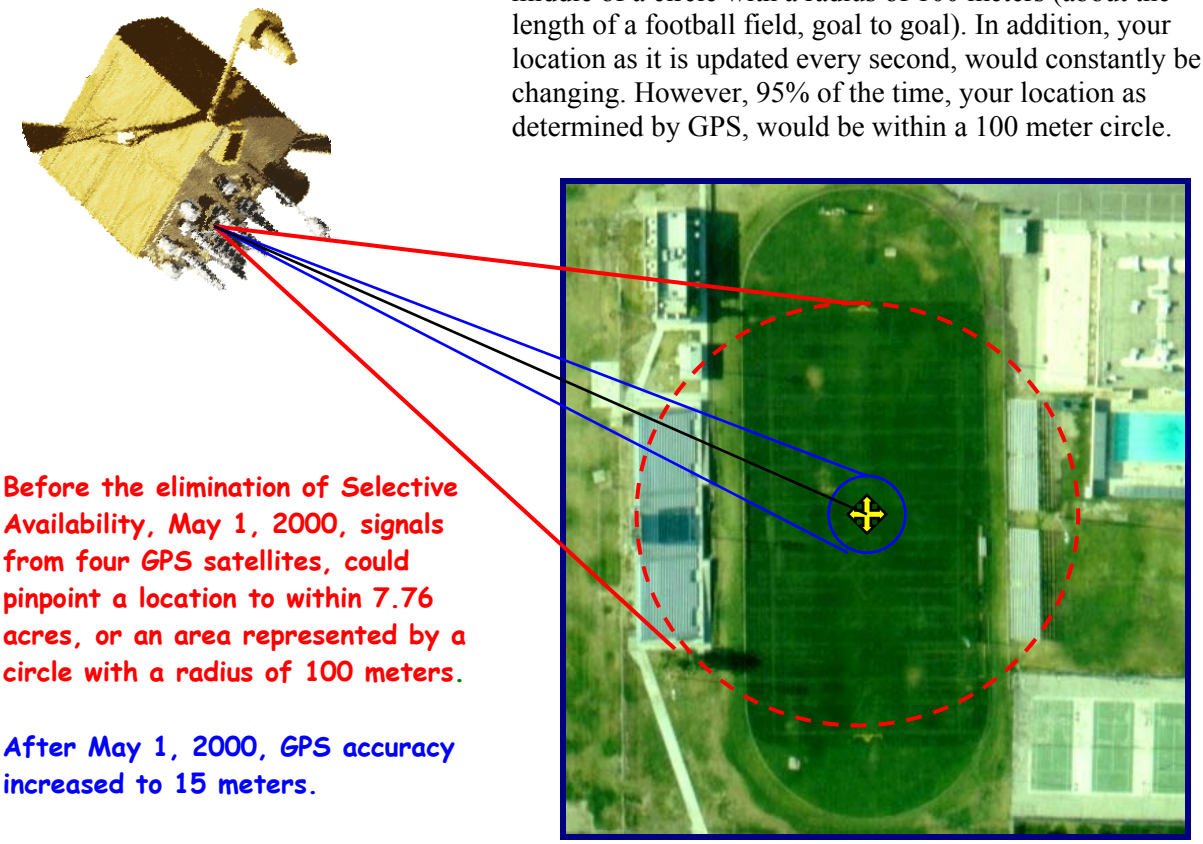
At the onset there was consideration for civilian use as well. To do this, NAVSTAR GPS provided and still does, two services: the Precise Positioning Service for the Military and the Standard Positioning Service for Civilians.

GPS Services

Standard Positioning Service - Civilian
The Standard Positioning Service (SPS) is available to anyone to use at no cost. SPS is governed by the Federal Radionavigation Plan, which specifies the level of accuracy, and integrity that the service must provide. The initial design of SPS included an introduced error known as Selective Availability (SA). This was done to protect our military capability and to make GPS ineffective for terrorist activities.

Selective Availability *is the result of intentionally introducing error into the GPS signal that generally constrained SPS to horizontal accuracies on the order of 100 meters.*

Imagine yourself with a GPS receiver, standing in the middle of a circle with a radius of 100 meters (about the length of a football field, goal to goal). In addition, your location as it is updated every second, would constantly be changing. However, 95% of the time, your location as determined by GPS, would be within a 100 meter circle.



Before the elimination of Selective Availability, May 1, 2000, signals from four GPS satellites, could pinpoint a location to within 7.76 acres, or an area represented by a circle with a radius of 100 meters.

After May 1, 2000, GPS accuracy increased to 15 meters.

By 2006, GPS modernization will improve accuracy to approximately

Differential GPS (DGPS) - Improving the Accuracy of GPS

The Service Center Agencies have a requirement for the horizontal accuracy of GPS positions to be better than 10 meters and in many cases better than 5 meters. Given the current positional accuracy of GPS is 15 meters 95% of the time how can the accuracy be improved?

> **DGPS** is a technique that corrects for some of the natural and introduced errors common to normal GPS observations, thus improving GPS positions.

DGPS corrections can be applied using post processing techniques or by using real time DGPS techniques. Post processing means you have collected GPS data and you will improve the GPS positions at a later time using additional information. Real time (R/T) means you are correcting and improving your GPS position immediately with additional information from R/T DGPS services. Obviously the difference is when you improve the GPS positions, now or later.

Real Time (R/T) DGPS Services

R/T DGPS services are provided by Commercial DGPS services and by Government DGPS services. Both Commercial and Government provided DGPS services to the user by either satellite-based systems or land-based systems.

1) Single Visit: Time is valuable and with mobile computing and telecommunications capabilities, GPS users can make decisions and complete their work immediately.
2) Increase Efficiency: R/T DGPS eliminates post processing and saves money and time and energy.
3) Better Products and Services: With R/ DGPS, the GPS user can provide better products and faster service to the customer.

Government DGPS Augmentations

Until recently, GPS users who wanted to get differential corrections had to pay a subscription fee to a private company or maintain their own base station in order to acquire differential corrections. Today, there are U.S. Government R/T DGPS services that are available to anyone at no cost:

Wide Area Augmentation System (WAAS)

The Wide Area Augmentation System, known as WAAS, is a satellite-based system, has been developed to meet Federal Aviation Administration (FAA) requirements for a safety-critical navigation system. It is what the name implies, a geographically expansive augmentation to the basic GPS service, designed for aviation. WAAS improves the accuracy, integrity, and availability of the basic GPS signals. This system will allow GPS to be used as a primary means of navigation for enroute travel and non-precision approaches in the U.S., as well as for Category I approaches to selected airports throughout the nation. The wide area of coverage for this system includes the entire United States and some outlying areas such as Canada and Mexico.

WAAS is a relative new system. WAAS is currently under development and test prior to FAA certification for safety-of-flight applications. Initial testing began in August 2000. Currently, while testing, there are planned outages. Even though WAAS is available throughout the U.S. it is still difficult to rely on. As WAAS becomes more capable, GPS receivers that also have WAAS capability will be very useful.

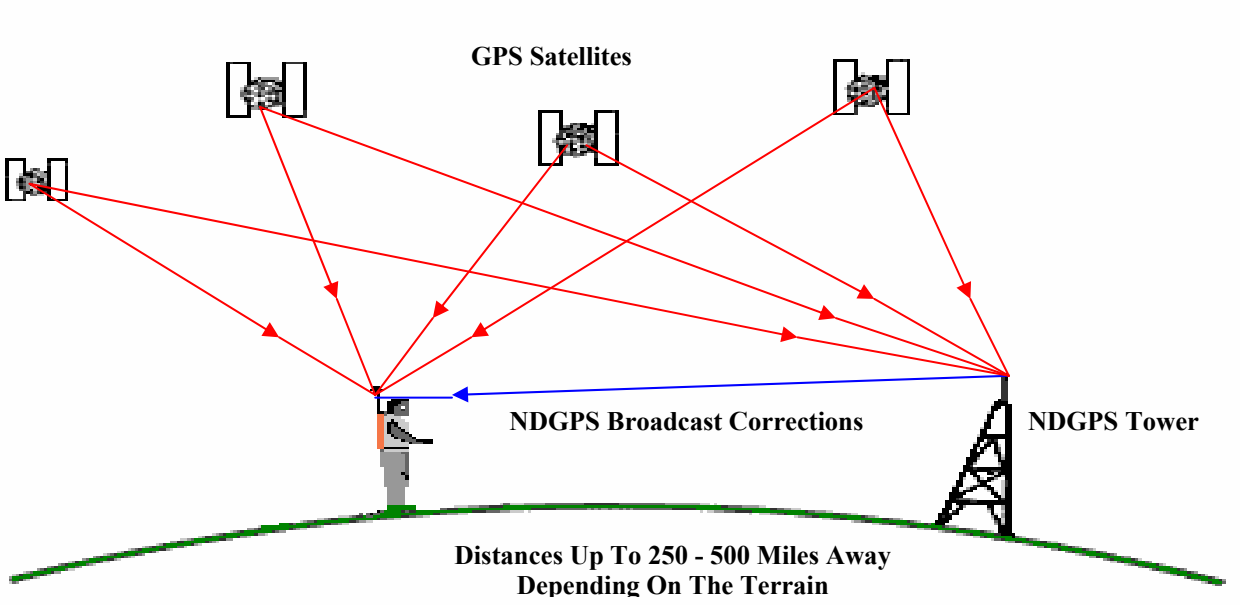
For now, the most useful Government DGPS augmentation is the Nationwide Differential Global Positioning System known as NDGPS.

Nationwide Differential GPS (NDGPS) Service

In 1990 the US Coast Guard (USCG) established a ground-based differential GPS, covering the coastal areas and navigable waterways. In 1994 a GPS Augmentation study was conducted and recommended that the Department of Transportation (DoT) expand the USCG's maritime system to provide continues marine and land coverage for surface users. In 1997, Federal agencies began planning for a DGPS system to provide Nationwide coverage; the Nationwide Differential GPS (NDGPS). [8]

Using the USCG's existing DGPS radiobeacon network as a template that provides coverage to both coastlines, the Gulf of Mexico, the Great Lakes, and major inland waterways, the NDGPS program intends to densify the existing network with dual redundant terrestrial and waterway coverage, providing service to the remaining 55 percent of the continental US and Alaska. [9]

Under an exemplary cooperative effort, many government agencies are contributing to this program. The US Air Force is making available a de-classified / de-commissioned network of emergency communications facilities, the Ground Wave Emergency Network (GWEN). A total of 53 GWEN sites located around the country will be converted from their old communications configurations to real-time GPS reference station installations. Differential corrections will be broadcast, at around 300 kHz, from 90-meter-tall GWEN transmission towers.



[8] ATIS News, "Nationwide Differential GPS" http://map.azfms.com/newsltr/vol3_1999/3ndgps.html

[9] Cook,Brendon, "The United States Nationwide Differential Global Positioning System", CSI, http://www.csi-dgps.com/csical/library/docs/pdf/csi-ndgps.pdf

Once fully operational, the NDGPS will cover the nation with the most accurate and reliable navigation system that the country has ever had. GPS users, both civilian and government, will have free access to the NDGPS. The NDGPS will augment the existing satellite system with ground-based radio transmitters, known as reference stations. The reference stations will broadcast a signal from a transmitter located at a known fixed location on the ground. Users who receive the ground-based signal in addition to the normal GPS satellite signals will be able to determine their position with greater accuracy. [1]

Reasons for Using NDGPS

There are six reasons for using NDGPS.

1) Real Time Horizontal Accuracies of 1-5 meters

The positional accuracy that is supported by the NDGPS system varies with the user's distance from the reference station. A good rule of thumb is that the horizontal accuracy can be determined by the following expression:

[0.5 meter + 1 meter / 150 kilometer separation + some receiver-dependent noise].

Example:
If you are 300 kilometers from the reference station, your accuracy will typically be around 3 meters. This accuracy refers to the real-time information displayed by the receiver, with no need to perform any kind of post-processing of the data.[3] Therefore NDGPS provides User the ability to navigate and acquire coordinates in real time with horizontal accuracies better than 5 meters.

Appendix 2 - NDGPS Horizontal Accuracy Verification, shows the results of two data captures at a known location, using GPS and NDGPS.

2) Availability - 99.7%

Availability for a given broadcast is defined as the percentage of time in a one-month period during which a DGPS broadcast transmits healthy correction signals at the specified output level. The current NDGPS is designed for, and is operated to maintain a broadcast availability level, which exceeds 99.7%.[10] This also meets USDA requirement for having availability of the real time DGPS signal whenever it is needed.

3) Reliability

System reliability is described by the probability of performing a specified function without failure under given conditions for a specified period of time; outages per million hours of operation. Once again this provides USDA with the insurance that the service is available when it is needed.

4) Integrity

System Integrity is the ability of the system to provide timely warnings to users when it should not be used for navigation. NDGPS integrity is provided by dual integrity monitors at each site. The integrity monitors ensure the integrity of the broadcast pseudorange

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[3] New Mexico Geographic Information Council, INC., "Differential GPS Coverage Coming Soon to New Mexico", http://nmgic.unm.edu/nmgcgpsc.htm

[10] D.B. Wolfe, C. L. Judy, E.J. Haukkala, D.J. Godfrey, "Engineering the World's largest DGPS Network", U.S. Coast Guard

corrections and broadcast an alarm message to the user if the corrections fall outside preset limits.[11] This provides additional security as to the positional quality of the signal.

5) **NDGPS is free and easy to use.**

6) **NDGPS is a system that has been developed, employed, and supported by the U.S. Government.**

Appendix 3 - NDGPS Coverage Map, shows the coverage of NDGPS prior to the last deployment.

Real Time GPS / NDGPS Equipment

To effectively used GPS and NDGPS in a single solution requires a complete system design. Each component of the system must be optimized for performance, must meet the functional requirements, and must work with all the other components of the system. The Real Time GPS / NDGPS System is a combination of a GPS receiver, Radio beacon receiver, a combination external antenna, and specially selected accessories, integrated into a single efficient and effective system. The major components of an NDGPS System include:

Dual GPS / Beacon Antenna
- Both receivers use the same antenna.
- Antenna is above the head for better reception.
- Antenna can be removed and attached to a range pole or using the magnetic mount, attached to a vehicle.

Backpack
- Small, lightweight, rugged
- Front pouch for pencils, notebooks

Radio Beacon Receiver
- Receives NDGPS differential corrections
- Small, lightweight, easy to remove

Cables & Battery
- Durable / dependable cables & connectors
- Rechargeable battery powers both receivers.

GPS Receiver
- Handheld - Easy to carry – Easy to use
- Download GPS data to PC or HPC
- Coordinates can be uploaded from GIS.

Additional Advantages of the Real Time GPS / NDGPS System

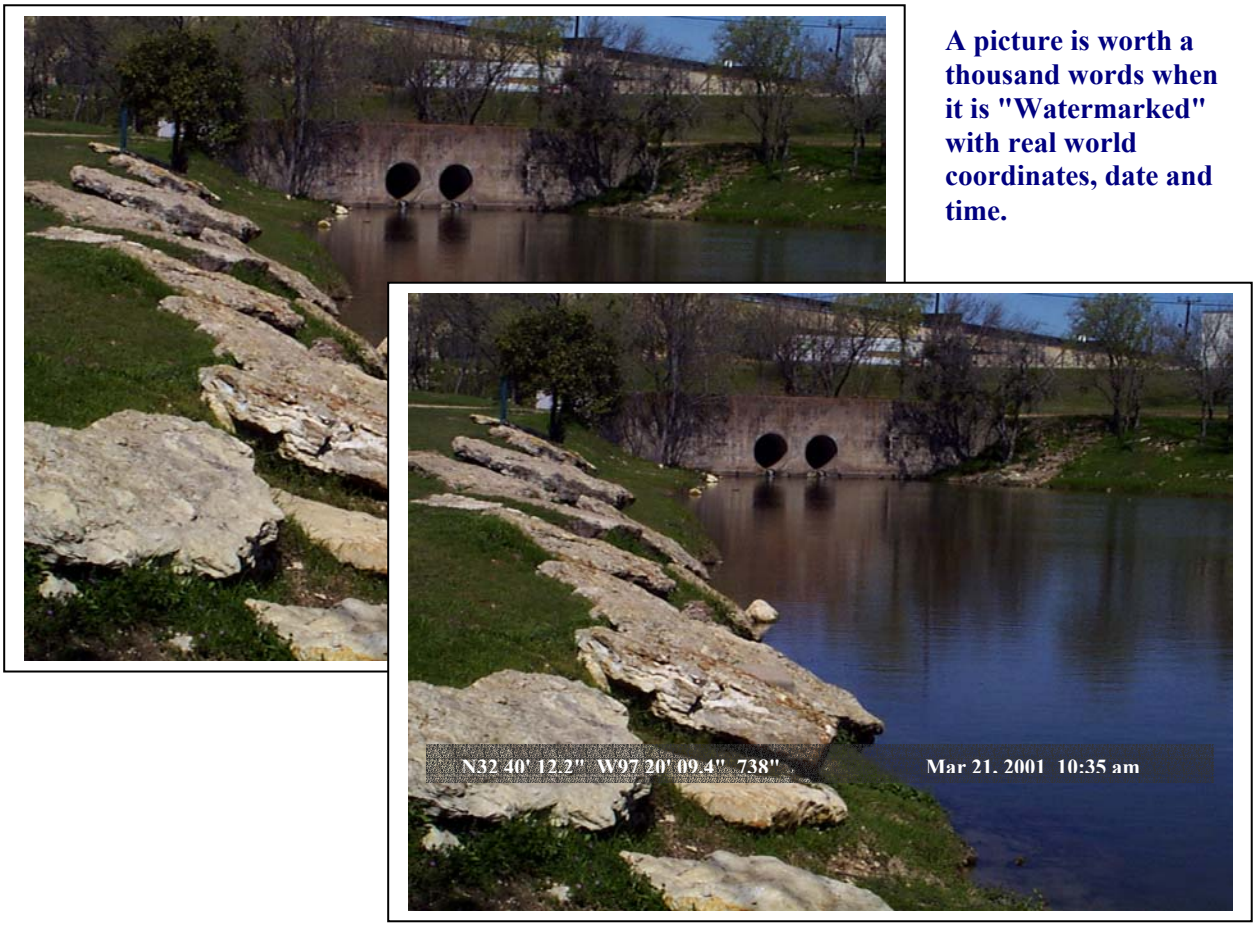
The Real Time GPS / NDGPS System provides a unique 2, 3, and 4-way communication capability, allowing the user, maximum flexibility to use a complement of equipment (Digital Cameras, laptops, and Handheld PCs) for field data collection. The system is designed with growth potential, enabling the user to start with the initial system and add additional components as needed.

[11] R. L. Ketchum, J.J. Lemmon, J. R. Hoffman, Institute for Telecommunication Sciences, "Site Selection Plan and Installation Guidelines for A Nationwide Differential GPS Service" August 5, 1997

PART - 3 DIGITAL CAMERAS

A Picture is Worth a Thousand Words!

Digital cameras provide a tremendous advantage for field data collection. Whether inventorying or monitoring natural resources, mapping, doing assets management, spot checking, or quality assurance, the best way to record existing conditions is with a digital camera referenced to location and time. An image, referenced to a real world location at a specific moment time, is evidence of an existing condition. In addition to being a "digital testimony: it is a permanent recording that is easily stored, retrieved, and used.



A picture is worth a thousand words when it is "Watermarked" with real world coordinates, date and time.

Integrating Digital Cameras with GPS

A digital camera integrating GPS achieves a unique and significant advantage over other imaging systems. Any camera, digital or photographic, can visually record a moment in time. Some sophisticated photographic systems can also record some camera parameters and any digital camera can add information to the digital image at will. What is unique and significant about a digital camera that has the capability of integrating GPS is the real time recording of metadata, the least of which would be coordinate location, date, and time. This integration requires a software implementation that provides communication between the digital camera and GPS receiver and software scripts that command the devices.

Watermarking

The ability for a digital camera to embed additional information into the image is known as watermarking. Watermarking can occur in two ways: in real time as the image is being acquired, or post acquisition - after the image has been acquired. The ability to watermark an image with GPS data (position, velocity and time) requires the digital camera to actively communicate with a GPS receiver and to stream over the GPS data to be watermarked into the acquire digital image. The great majority of the available digital cameras are not GPS capable, meaning they do not have the ability to integrate GPS data such as horizontal coordinates, elevation, date, and time from the GPS receiver. This integration requires a software implementation that provides communication between the digital camera and the GPS receiver.

Digita Operating System

The Digita operating System is an open-architecture operating system for imaging devices that provides the capability of the digital camera to integrate GPS data. Digita enables licensed partners and developers to create custom solutions. Digita licensees include Eastman Kodak, Epson, Hewlett-Packard, Konica, Minolta, and Sharp.

USDA Service Center Digital Camera Functional Requirements

- Easy to use.
- Lightweight, portable.
- Takes quality photos.
- Auto focus.
- Zoom.
- Close up capability.
- GPS compatible.
- Embeds the GPS position, elevation, date, and time into the image.
- Removable memory cards.
- PC download capability.
- Complete system with protective case and accessories, including cables and/or peripherals necessary for GPS interface.

USDA Service Center Digital Camera Operational Requirements

- Two-megapixel resolution
- Auto focus
- Viewfinder
- Multiple image resolution
  - selectable
  - interpolated
- Variable image compression
- Variable shutter speed
- Variable focus range
- Variable aperture range
  - Wide angle
  - telephoto
- High CCD resolution
- 3:1 Optical Zoom
- File format
  - JPEG
  - TIFF
- Exposure Compensation
- Exposure control
  - Auto
  - Manual
  - Exposure lock
  - Focus distance and exposure time
- User interface
  - Graphical
  - Menu-driven
  - Easy to navigate
- External Flash
  - Strobe
  - Synchronized
  - Flash range up to 12ft.
- Removal memory
- Time lapse capture
- Tripod mount
- Additional Lenses
- Power
  - Ac Adapter
  - Alkaline and rechargeable batteries
- Connectivity
  - Audio out
  - IrDA
  - Std. Serial
  - USB
  - Video out
- GPS Compatible
- Scripting
  - DIGITA text-based language
  - Graphic watermark
  - Text watermark
- Lightweight, < 1.5 lbs.

PART - 4 RECOMMENDATIONS

Team Recommendations for GPS Implementation

1) Develop a procurement vehicle that allows Service Center Agencies to acquire additional GPS Systems or components beyond those purchased as part of an initial procurement.

2) The GPS Systems should be shipped as a complete package from the vendor, directly to the identified locations.

3) Develop training, support, and infrastructure needed to implement GPS at the Service Center level, including:

   - As a minimum, identify and develop one key GPS leader (Tier 1) for each Agency at each Service Center.
   - At the state level, identify a State GPS Coordinator (Tier 2) for each Agency.
   - For each Agency, identify a National GPS coordinator, (Tier3).
   - Develop agency specific GPS Application manuals.
   - Develop a statewide training plan and process for each agency and provide training to coincide with the delivery of the GPS equipment.

4) Develop and deploy the ArcView/GPS interface to Service Centers in conjunction with the deployment of GPS Systems.

5) Establish two standard GPS system configurations. Configuration 1 is the HIGH option and is Real Time GPS/NDGPS System. Configuration 2 is the LOW option with standard GPS capability. Both configurations have a backpack and antenna and have a common GPS receiver. Configuration 2 does not have a NDGPS receiver.

   The following recommendations represent the total GPS system need and are basically listed in priority order. Initial procurement should address these needs in priority order as far as funding allows.

6) Acquire a minimum of one Real Time GPS/NDGPS System (Configuration 1) each for FSA and NRCS for all Service Center locations where there is NDGPS coverage.

FSA	Service Centers Offices	2381
NRCS	Service Center Offices	2527
RT GPS/NDGPS System (Config.1)	**TOTAL**	**4908**

7) Acquire an additional Real Time GPS/NDGPS System (Configuration 1) for each "larger" FSA Service Center offices (field offices with 5 or greater FSA Service Center staff).

FSA	Service Centers Offices	1360
RT GPS/NDGPS System (Config. 1)	**TOTAL**	**1360**

8) Acquire additional Real Time GPS/DGPS System (Configuration 1) for each Service Center Agency's Sate Office and other special offices.

FSA	State Office	52
	Program delivery Point	7
NRCS	State Offices	53
	Area Offices	96
	Program Delivery Point	136
	Soil Survey Offices	774
	Water Quality Offices	8

	Watershed Project Offices	34
	Plant Material Centers	25
RD	State Offices	48
RT GPS/NDGPS System (Config. 1)	**TOTAL**	**1233**

9) Acquire GPS Systems (Configuration 2) as needed for each agency.

FSA	State Office	52
NRCS	Service Centers	4132
	State Offices	53
	Water Quality Offices	16
	RC&D	321
RD	Area Offices	141
	Service Centers	657
	Program Delivery Point	9
GPS System (Config. 2)	**TOTAL**	**5381**

Team Recommendation for Digital Camera Implementation

3) Establish one standard camera configuration.

4) Acquire Digital cameras with Compact Flash Card readers for Service Centers, State offices, and other special offices.

FSA	Service Centers	2381
	State Office	52
	Program delivery Point	7
NRCS	Service Centers	2527
	State Offices	53
	Area Offices	96
	Program Delivery Point	136
	Soil Survey Offices	287
	Water Quality Offices	8
	Watershed Project Offices	34
	Plant Material Centers	25
	River Basin Project Office	1
	RC & D Offices	705
	SNOTEL Office	1
	Grazing Lands Technology Insti.	6
RD	Service Centers	657
	State Offices	48
	Area Offices	141
	Program Delivery Point	9
Digital Cameras & Flash Card Readers		**TOTAL 7174**

APPENDIX 1

USDA GPS / Digital Camera Service Center Team Members

USDA GPS / Digital Camera Service Center Team

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APPENDIX 2

NDGPS Horizontal Accuracy Verification

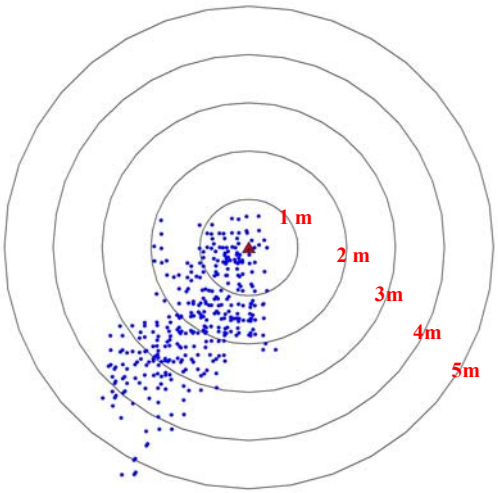
NDGPS Horizontal Accuracy Verification

When verifying how accurate NDGPS is, simultaneous observations are made of the GPS Standard Positioning Service and the R/T NDGPS service. These observations are made with the respective receivers; a GPS receiver for the GPS signals in space and a Radio Beacon receiver for the ground based NDGPS signals. Observations are made at a FBCN Monument where the absolute coordinates are well known and the difference between the absolute position and the observed position can be calculated. These calculations provide not only linear but directional differences.

Antenna Array

FBCN Monument CS 2429
(Aledo 3)
Aledo, Parker County, Texas

Receiver Test-bed



5 March 2001
10:25 to 11:30 CST
Garmin 3 Plus with CSI MBX3 DGPS RCVR
5 Second interval data collection

Point Accuracy	Count	% of Total
Less than 1 meter	191	28.30
1 to 2 meters	225	33.33
2 to 3 meters	144	21.33
3 to 4 meters	92	13.63
4 to 5 meters	16	2.37
5 to 6 meters	7	1.04
Total points collected	675	100.00

2 May 01
9:43 to 10:50 CST
GPS Map76 with CSI ABX3 DGPS RCVR
10 Second interval data collection

Point Accuracy	Count	% of Total
Less than 1 meter	1	0.24
1 to 2 meters	11	2.66
2 to 3 meters	24	5.80
3 to 4 meters	232	56.04
4 to 5 meters	90	21.74
5 to 6 meters	56	13.53
Total	414	100.00

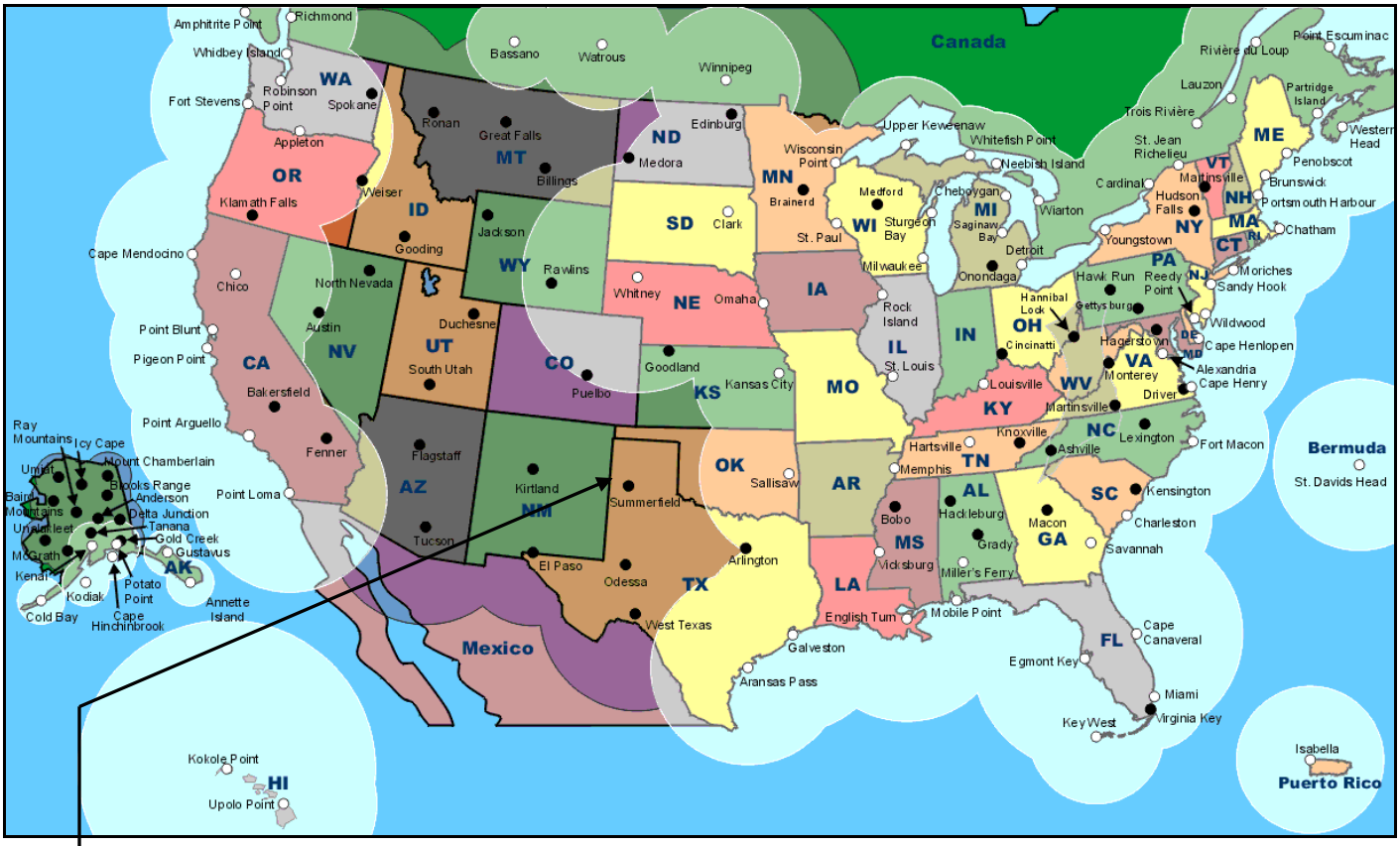
APPENDIX 3

NDGPS Coverage Map

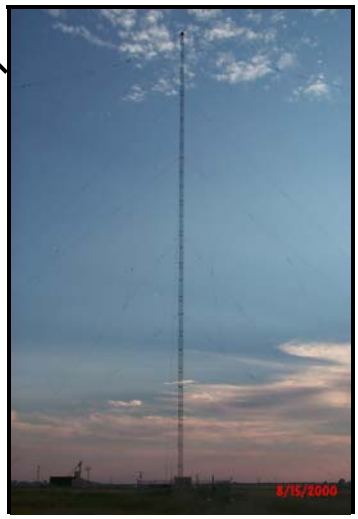
NDGPS Coverage Map

Appendix 3

NDGPS is rapidly expanding coverage across the U.S. The signal coverage for the radiobeacon transmitters is aided by the use of medium frequency 285-325 kHz band, which provides the advantages of a large coverage with low power transmitters, and a minimum effect of terrain features on the propagation of radio waves. Redundancy of the DGPS signal is obtained by designing the network of broadcast sites to provide overlapping coverage of the radiobeacon signal so that at least two DGPS correction signals can be received at most locations, nationwide.



Additional Sites, like Summerfield, TX have been added to the NDGPS network. Check current status map on http://www.navcen.uscg.mil/dgps/status.htm



Summerfield, Texas

Status:	Operational
RBn Antenna Location	34* 49.2' N 102* 30.6' W
REFSTA Ant Location (A)	34* 49.50344' N 102* 30.70571' W
REFSTA Ant Location (B)	34* 49.50331' N 102* 30.72375' W
REFSTA RTCM SC-104 ID (A)	52
REFSTA RTCM SC-104 ID (B)	53
REFSTA FIRMWARE VRSION	RD00-1C19
Broadcast Site ID	823
Transmission Frequency	318 KHZ
Transmission Rate	100 BPS
Signal Strength	75uV at 230 SM

APPENDIX 4

Questions & Answers

Since the government stopped degrading the GPS signal, I have heard that GPS can provide accuracies as good as 2-3 meters. Is that true?

Eliminating Selective Availability (SA) was a tremendous benefit to GPS users worldwide. Since this occurred recently (May 1, 2000), new signal specification for the Standard Positioning Service, the GPS service available to everyone, is now being adopted. The new specification is based on accuracy and availability of the signal. The new SPS specification requires that the worst case horizontal accuracy will be as good as 15 meters, 95% of the time. It is true that the best case GPS positions are much better than 15 meters and sometimes as good as 2-3 meters. However, you can not expect the best case all the time nor can you tell when the best case will occur. Remember that GPS is a dynamic system with many factors effecting the quality of position. The quality of position not only changes over time, but can do so from minute to minute or hour to hour.

I am not sure what my accuracy requirements are. How can I determine what kind of accuracy I need?

The best way to determine what kind of accuracy you need is to consider the work you do and the individual tasks that you will be using GPS for. Determine what kind of GPS positional information you need (points, lines, and polygons) and which is more important: horizontal accuracy, vertical accuracy, or both.

- If vertical accuracy is more important, especially if you are doing topographical mapping, leveling, site design, etc., then you probably need vertical accuracies less than one meter and probably less than one foot. If so, you need to use GPS Survey-grade equipment and techniques. Survey-grade is a more sophisticated approach to GPS.
- If horizontal accuracy is more important, then you have more options. If you are using GPS as a navigation tool, then how close do you need to get to where you are going? Close enough to see your vehicle or close enough to stand on a certain place on the landscape? If you are using GPS as a positional tool, how accurate do you want that position to be?
- If vertical and horizontal accuracies are equally important, the vertical accuracy may be the limiting factor. Determine how accurate both need to be to satisfy your job requirements.

If I want to use GPS for mapping and collecting geospatial data for GIS, what should I use?

Most mapping and GIS applications require horizontal data to be accurate to at least 10 meters. More importantly, the positional data must be consistent, allowing for revisit and update capabilities. To constantly achieve less than 10 meter horizontal accuracy, the GPS user must use Differential GPS (DGPS) equipment and techniques.

What is DGPS and how can I use it? Is there a cost?

DGPS simply means using additional positional information, generally referred to as differential corrections, to improve the GPS position. There are many sources of additional positional information or DGPS corrections. There are satellite based and land based DGPS systems. There are commercial systems that charge a subscription fee for access to their DGPS corrections. There are also US Government DGPS systems that provide free land based and satellite based DGPS Corrections. These DGPS sources, commercial or governmental, both provide DGPS corrections that will consistently improve the accuracy of a GPS position to within 1-5 meters.

How can I get the DGPS corrections while I am using GPS?

Like GPS, DGPS corrections are signals that travel through space. It requires an additional receiver that is designed to receive the DGPS corrections. Having received these corrections, they are transferred immediately to the GPS receiver that provides a corrected position with improved accuracy in real time.

What kind of equipment do I need?

That depends on the source of the DGPS corrections. The commercial sources for DGPS corrections sell they're own receivers that are specifically designed to receive the corrections broadcast from their

geostationary satellites. There is an annual subscription fee for access to the signal from their satellites. This is the same concept as digital satellite television. You buy the equipment and pay for the service.

What about the free government broadcast correction systems?

There are two government, free for use, DGPS systems.

- The Wide Area Augmentation System, known as WAAS, is a satellite-based system, has been developed to meet Federal Aviation Administration (FAA) requirements for a safety-critical navigation system. It is what the name implies, a geographically expansive augmentation to the basic GPS service, designed for aviation. WAAS improves the accuracy, integrity, and availability of the basic GPS signals. This system will allow GPS to be used as a primary means of navigation for enroute travel and non-precision approaches in the U.S., as well as for Category I approaches to selected airports throughout the nation. The wide area of coverage for this system includes the entire United States and some outlying areas such as Canada and Mexico.

- The Nationwide Differential GPS System, known as NDGPS, is a ground-based system, which broadcasts corrections from towers. The NDGPS network design is based on the U.S. coast Guard's DGPS Maritime Service that began initial operation in 1996 with service coverage of major harbors and the nations coastline. With the addition of the inland sites, NDGPS is the world's largest ground-based GPS augmentation service. NDGPS is being implemented to meet all surface transportation navigation requirements for the U.S.

Are there other differences between WAAS and NDGPS?

Yes. There are a couple of differences to keep in mind.

WAAS is a relative new system. WAAS is currently under development and test prior to FAA certification for safety-of-flight applications. Initial testing began in August 2000. Currently, while testing, there are planned outages. Even though WAAS is available throughout the U.S., WAAS receivers are more expensive and less available than NDGPS receivers.

The NDGPS system is a continuation of a GPS augmentation that began in 1993 and was operational in 1996. Each broadcast site of the NDGPS is required to be on-air and monitored in real-time by a centralized control Station 99.7% of the time. NDGPS radio beacon receivers are cheaper and more available than WAAS receivers are.

What benefits does NDGPS offer?

NDGPS offers two major benefits. First, the NDGPS systems provide more capability and a higher level of accuracy. Second, NDGPS provides integrity to GPS data. Anytime a GPS user is collecting field data to support mapping or GIS applications; the data should be accurate and dependable.

Is NDGPS available everywhere?

Not at this time. If you refer back to the NDGPS Coverage Map, you will see areas that do not have coverage. Each year additional sites are planned and scheduled for construction.

If I want to use GPS and improve the accuracy with NDGPS, do I just buy two receivers?

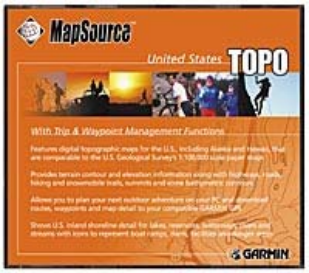
No. It is important to have a complete NDGPS System with a differentially correctable GPS receiver and a dual frequency radio beacon receiver, an external dual GPS/radio beacon antenna, and all the cables and the power support that you will need. The system should be compatible, efficient, and easy to use.

What about areas that don't have NDGPS coverage?

NDGPS is spreading across the country rapidly. If you don't have coverage, you soon will have. For areas that currently do not have NDGPS coverage, and you want to use GPS, consider purchasing just the DGPS receiver. When NDGPS coverage is available for your area, you can purchase the rest of the NDGPS system and you will be ready to go.

How valuable is the Moving Map capability?

The moving map display is very useful. The Topo MapSource software comes with a background line map of contours and drainage patterns. Your GPS position is plotted on the topo and displayed on the screen. Of course, as you move the screen display changes, reflecting your position on the topography. This happens automatically whether you are walking, riding, or even flying across the terrain. If you are navigating to a certain point, or acquiring points, lines, or areas in a large field, the moving map feature is very valuable. The road display on the maps is really valuable when you are working in unfamiliar areas or providing assistance after natural disasters.



The MapSource™ United States TOPO CD-ROM maps are similar to U.S. Geological Survey 1:100,000-scale topographic paper maps. United States TOPO includes trip and waypoint management functions that allow you to transfer waypoints, routes, and tracks between your PC and nearly all GARMIN GPS units. With MapSource, you can view highways, roads, hiking trails, snowmobile trails, backwoods trails, elevation contours, point elevations, summits, some bathymetric contours, geographic names, churches, and schools. Shoreline detail is included for lakes, reservoirs, small bodies of water, waterways, rivers, and streams. Icons represent boat ramps, dams, marinas, campgrounds, public facilities, mile markers, first-aid stations, picnic, swimming, and ski areas, wrecks, fuel, and dangerous and restricted areas.

How much does the system weight? Is the backpack necessary?

The entire system loaded, backpack included, weights about 10 lbs. The backpack is necessary because it is important to have the antenna above your head and you have to have some place to put the NDGPS receiver, battery, and extra cables. The backpack is also useful for storing pens, pencils, notebooks, maps, forms, or even your lunch. The backpack is rugged and comfortable.

Easy access to front panel storage

Access beacon receiver from top

How hard is it to hook up and get running?

One of the biggest considerations in designing the NDGPS systems was the field requirement for rapid and easy use of the equipment. After numerous designs, the NDGPS system described is very straightforward and easy to use. Each system comes with a diagram for cabling the equipment together. Once you receive the equipment, it shouldn't take more than an hour, following the instructions, before you are outside collecting data. After that, it is just a matter of grabbing the backpack on the way out the door. When you are ready to collect data, turn on the Radio Beacon receiver, the GPS receiver, and within a few minutes you should be locked on to the radio beacon and receiving GPS signals. Your corrected GPS positions will be displayed automatically on the moving map and you are ready to go.

Can I use the NDGPS system in a truck or on an ATV?

Yes. That was another field requirement; the ability to use with and remove from vehicles for mobile use. The NDGPS systems have external power adapters for battery or vehicle power. The external dual GPS/NDGPS antenna can be mounted on the backpack, a range pole, or magnetically mounted on a vehicle. Cable lengths are long enough to throw the backpack on the seat of the truck, plug the power cable into the cigarette lighter, and attach the antenna to the top of the cab. When you are using an ATV, the cables are long enough to get off the ATV and hold the antenna over a fence post or some other feature you can not drive over.

Can I hook the NDGPS system to a notebook and download GPS positions and run an ArcView application?

Yes. Since most natural resource applications are in the field, it was important to be able to actively communicate with a notebook or some other mobile computing device to enable field personnel to run the programs they might need. That includes interfacing with ArcView. That is one of the reasons the NDGPS has 4-way communication capability.

Do you need additional software to download the GPS data into ArcView?

Yes, you need the Waypoint + software that comes with the GARMIN receiver and a free ArcView GARMIN Extension called avgarmin.avx. This allows GPS data to be manually downloaded from GARMIN receivers using Waypoint+ and then using existing Avenue scripts for conversion into an ArcView shapefile.

Can I use the NDGPS system with a handheld personal computer?

Yes, that is a natural progression for using GPS. The advantage of real time directly to a handheld personal computer (HPC) provides the capability for mobile computing. Again, that is why there is 4-way communication capability with the NDGPS System. With 4-way communication, you can simultaneously use a GPS receiver, radio beacon receiver, digital camera, and a computing device.

Will these NDGPS Systems become outdated?

NDGPS is a national system funded by congress and operated by the U.S. Coast Guard. There are many safety of life applications that require NDGPS. It was declared to be operationally capable in 1996 and will continue its usefulness for a very long time. The particular equipment that is recommended will continue to work with the NDGPS system as the system grows.

APPENDIX 5

Global Positioning System (GPS) & Digital Camera Unit Availability and Capability Survey

United States Department of Agriculture Service Center Agencies

Global Positioning System (GPS) & Digital Camera

Unit Availability and Capability Survey

Farm Service Agency
Natural Resources Conservation Service
Rural Development

Contents

Global Positioning System (GPS) & Digital Camera

Unit Availability and Capability Survey

Purpose
The purpose of this document is to 1) describe the functional and operational requirements for Global Positioning System (GPS) equipment and Digital Cameras for USDA Service Center Agencies and 2) to describe USDA Service Center Agencies specifications for:

- Real Time GPS/NDGPS System (Configuration 1)
- GPS & Antenna System (Configuration 2)
- Digital Camera System
- GPS-Digital Camera Integration Software

These systems and their components have been especially designed and specified to meet the business functions of the Service Center Agencies.

USDA Service Center & Agencies
The United States Department of Agriculture provides conservation and rural development services to maintain a viable agricultural production base, to protect the environment, and to help rural America grow and prosper with the rest of the nation. These services are provided by three USDA agencies: The Farm Service Agency (FSA), the Natural Resources Conservation Service (NRCS) and Rural Development (RD). Over the past several years, the USDA has co-located FSA, NRCS, and RD at the county level by establishing Service Centers to deliver USDA programs and services from a single location. Approximately 2,600 Service Centers are now in place. The Service Center Agencies are staffed by 35,500 employees, equal to nearly one-third of the entire USDA workforce. The Service Centers are assisted by 8,000 conservation volunteers as well as over 7,000 local soil and water conservation district employees, most of whom are co-located with NRCS.[12]

Of the technologies implemented by the Service Centers, Geographic Information Systems (GIS) and Global Positioning System (GPS) will have the greatest and longest lasting impact on the products and services provided to customers. It is natural to associate agricultural business with the land and USDA programs are linked spatially to digital maps. Providing high quality, geospatial data sets for internal program use and to the public and private sector is a critical part of the USDA mission.[13]

USDA Service Center GPS and Digital Camera Systems
USDA Service Center Agencies have business functions and information needs that require GPS and Digital Cameras for field data collection. Each Service Center Agency developed functional and operational requirements relative to their needs for GPS and digital cameras. These Agency requirements were used to develop the included specifications for GPS equipment and digital cameras.

[12] USDA, "Service Center Modernization Initiative Information Technology Blueprint, Improving Service to Agriculture and Rural America", USDA, December 2000
[13] USDA, "U.S. Department of Agriculture, Enterprise GIS Acquisition" USDA April 2001

Step 1 - Reviewing Unit Availability and Capability Survey

The first step in the down selection process for considering individual GPS receivers was to review a market survey and develop a list of potential equipment for consideration. There are many companies that manufacture, sell, or resell GPS equipment. "The most complete reference to GPS equipment available in one place" can be found in the January 2001 issue of GPS World.[14] The listing contains information from 67 manufactures about 518 receivers.

The listing provides the following data about each of the receivers:

- Manufacture
- Model
- Introduction Date
- Channels/Tracking Mode
- Signal tracked
- Max. number of satellites tracked
- User environment and application
- Size
- Weight
- Position (Autonomous / Differential / Post Differential
- Time (nanoseconds)
- Position fix update rate (seconds)
- Cold Start
- Warm Start
- Reacquisition
- Number of Ports
- Port Type
- Baud Rate
- Operating Temperature
- Storage Temperature
- Humidity
- Power Source
- Power Consumption
- Antenna Type
- List price

In reviewing the listing of 67 manufactures and 518 receivers, there dare certain features that a GPS receiver must have to be able to be considered for USDA Service Center use:

- Form Factor - Handheld
- Signal tracked - L1, CA code
- Minimum Number of Satellites tracked - 12 GPS
- Differentially Correctable - Real Time
- Application - Terrestrial
- Operating temperature - to meet field conditions
- Power Source - both external and internal
- Antenna - internal and external
- List Price - Less than $500.00

Step 2 - Identification of GPS Receivers for Evaluation.
By comparing the above features with the market survey data, certain GPS receivers were identified for further consideration for USDA Service Center use.

Manufacture	GPS Receivers
Brunton	Multi-Navigator
Garmin	GPS 12, GPS 12CX, GPS 12MAP, GPS 12XL, GPS II Plus, GPS III Plus, GPS 48, GPSMAP 76
Lowrance	GlobalMap 100, GlobalMap 100 Plus
Magellan	Magellan 310, GPS 315, Map 330, Map 410,

[14] GPS World, GPS World Receiver Survey, January 2001, pg. 32 - 47

Step 3 - Matching Potential Receivers with GPS Requirements
The 15 GPS receivers identified for further consideration can be compared to the USDA Service Center GPS Operational Requirements (ORD). The objective is to identify as many GPS receivers as possible that will have the functions and features required for Service Center use.

An extremely important consideration when comparing functions and features of each potential GPS receiver is the requirement to accept and use differential corrections. That means the ability to not only to receive and process RTCM-104 but also to physically connect to a radio beacon receiver, power, and a dual external GPS/DGPS antenna. It is the requirement of real time differential that will ultimately provide the accuracy and consistence that is required for navigation and positioning.

After comparing functions and features with GPS requirements and considering the requirement for real time Differential GPS, there were three GPS receivers identified for further consideration.

Manufacture	GPS Receiver
Garmin	GPS III Plus, 12XL, GPSMAP 76

Step 4 - Develop a Comprehensive Comparison Matrix
Having down selected to three GPS receivers, each receiver was evaluated for functional capability and performance.

Appendix 1 - GPS Receiver Comparison Matrix

USDA Service Center GPS Functional Requirements

- A real time, 1- 5-meter navigation and positioning system.
  - The ability to use the NAVSTAR Global Positioning System's Standard Positioning Service and the Nationwide Differential Global Positioning System (NDGPS) to achieve real time navigation and positioning with accuracies of 1-5 meters.
- Complete.
  - The USDA Service Center GPS System must be delivered as a complete unit to each designated Service Center.
- Common.
  - Each Service Center Agency will have the same equipment that will meet the Individual business functions of each Agency.
- Durable.
  - The GPS System and components must withstand every day field use; outdoor conditions, sunlight, temperature, moisture, dust, etc.
- Reliable.
  - The equipment must perform every time, all the time.
- Easy to use.
  - The equipment must be easy to assemble and easy to use. Start-ups and set- ups must be accomplished successfully without error.
- Inter-operateabilty
  - The GPS System must operate internally as well as externally with the Common Computing Environment
- Functionality
  - As described in the GPS Operational Requirements.

USDA Service Center GPS Operational Requirements

- **Real Time Navigation**
  - Real Time Navigation using GPS and NDGPS
  - Navigate to pre-determined locations = Points
  - Navigate between two or more points = Lines (Routes)
  - Navigate around cultural or natural features = Polygons (Routes)
- **Positioning**
  - Real Time Positioning using GPS and NDGPS
  - Mark and auto-mark waypoints
  - Create track files and routes
  - Determine distance and direction between points,
  - Automatically calculates area of polygons from saved track files.
- **Communication**
  - Interface with the USDA Common Computing Environment.
  - Download coordinates from the GPS receiver to specified GIS.
  - Upload coordinates from specified GIS to GPS.
  - The GPS should allow for four-way real time communication between the GPS receiver, the Beacon Receiver, a Digital Camera, and an HPC or notebook
- **Small & Lightweight**
  - All components of the GPS System will fit into a small backpack, < 1320 cubic inches.
  - Backpack and components will weight less than 12 pounds.
  - The GPS System will allow for quick and easy removal to and from vehicles
- **Rugged**
  - Ability to withstand every day field operations.
  - All cables and connectors will be strong, durable, and allow for repeated connecting and unconnecting of components as needed.
- **Environmental Tolerance**
  - All components should operate in temperatures ranging from 5 F - 120 F,
  - Exposed components will be moisture proof and unaffected by humidity or light to moderate rainfall.
  - All Components will be sealed to avoid dust and dirt.
- **Graphic Display**
  - All displays will be easy to read, indoors and outdoors (sunlight readable).
  - All displays should have adjustable back lighting.
  - Screen displays should be logically ordered.
  - Information displayed on the screen should be easy to read.
- **Antenna Configurations**
  - The GPS receiver will have an internal antenna and capability of using an external antenna.
  - The GPS System will have a dual GPS / Beacon external antenna with necessary cabling.
- **Operation Duration**
  - The GPS System should have the ability to power the GPS receiver, the Beacon receiver, and additional equipment like a Digital Camera and a Handheld Personal Computer (HPC) or Notebook from a single external battery for up to 10 hours of continuos operations.
- **External Power Source**
  - The GPS System will have the ability to be powered from a vehicle using a cigarette lighter adapter and cable.
  - The GPS System should allow recharging the external battery simultaneously while using vehicle power.
- **Navigational Aids**
  - Moving Map Display: Roads and Cities, Topography
- **Product availability**
  - The GPS System will be available for purchase, as individual units on an as needed basis as well as in large quantities.
- **Start Up**
  - The ability to use the GPS System with a minimum investment in training. This includes the assembly of all GPS System components: including GPS receiver,

differential beacon receiver, antennas, cabling and other part, before delivery to Service Centers.

Digital Camera

Unit Survey for Digital Cameras

During the last 1-2 years, there has bee a proliferation of Digital Cameras available in all price ranges from a few hundred dollars to thousands of dollars. This insurgence of digital cameras into the traditional camera market is the result of camera users being influenced by home and business computing and the ability to transfer image files over the Internet.

There are approximately 20 manufactures of digital cameras with 12 manufactures (AGFA, Cannon, Casio, Epson, FujiFilm, HP, Kodak, Minolta, Nikon, Olympus, Sony, and Toshiba) accounting for most of the digital camera models. Numerous Internet searches can be conducted to identify digital cameras by various categories. An Internet search on digital cameras based on, cameras with greater than 2.0 megapixel resolution, priced between $300. - $700.00, yields about 35 digital cameras. Some of these cameras have actually been discontinued by the manufacture, yet still show small quantities available from distributors.

An important criteria for reviewing the current digital camera market is a unique requirement that USDA has identified as an operational requirement for Service Center operations; Watermarking.

Watermarking
Some digital cameras have the ability to embed additional text information into the image. This is called Watermarking and can occur in two ways: in real time as the image is being acquired, or post acquisition - after the image has been acquired.

The ability to real time watermark an image with GPS data (position, date, and time) requires the digital camera to actively communicate with a GPS receiver and to simultaneously stream over the GPS data to be watermarked onto the acquire digital image. The few cameras that had the capability of watermarking in real time have been discontinued by the manufactures. This seems to be in response to a limited market for, what would be a more expensive solution and limited to those who have GPS receivers.

"Post Watermarking" is a process that allows the date and time in the image file from the digital camera to be "synchronized" with the position, date, and time data from the GPS receiver. This allows the transfer of the GPS data to the image file, creating the watermark on the image. Additional software is required to make this process work.

For a digital camera to be able to post watermark images the digital camera must be capable of storing date/time information in the JPEG image file using EXIF format; JPEG(EXIF)

Other important considerations for digital cameras come from the USDA Service Center functional requirements.

USDA Service Center Digital Camera Functional Requirements

- Easy to use.
- Lightweight, portable.
- Takes quality photos.
- Auto focus.
- Zoom.
- Close up capability.
- GPS compatible.
- Embeds the GPS position, elevation, date, and time into the image.
- Removable memory cards.
- PC download capability.
- Complete system with protective case and accessories, including cables and/or peripherals necessary for GPS interface.

A further search using the criteria of 2+ megapixel resolution and JPEG(EXIF) Format yielded 6 manufactures and a total of 14 possible digital cameras.

Manufacture	Camera	Average Retail Cost
Agfa	ePhoto CL45	$350
Cannon	Digital IXUS 300	$600
	PowerShot S300 Digital Elph	$550
FujiFilm	FinePix 2300	$280
	FinePix 40i	$550
	FinePix 50i	$650
HP	PhotoSmart 618	$500
	PhotoSmart 912	$900
Kodak	DX 3500	$379
	DX 3600 Zoom	$479
	DC 3400	$400
	DC 3800	$400
	DC 5000	$600
Sony	DSC-P50	$400

The above two criteria of resolution and file format, combined with the other operational requirements will define potential digital cameras that will meet Service Center requirements.

USDA Service Center Digital Camera Operational Requirements

- Two-megapixel resolution
- Auto focus
- Viewfinder
- LCD Display
- Multiple image resolution
  - selectable
  - interpolated
- Variable image compression
- Variable focus range
- Variable aperture range
  - Wide angle
  - telephoto
- High CCD resolution
- 3:1 Optical Zoom
- Exposure Compensation
- Exposure control
  - Auto
  - Manual
  - Exposure lock
  - Focus distance and exposure time
- User interface
  - Graphical
  - Menu-driven
  - Easy to navigate
- External Flash
  - Strobe
  - Synchronized
  - Flash range up to 12ft.
- Variable shutter speed
- File format
  - JPEG(EXIF)
- Removal memory
  - Serial Card Reader
- Connectivity
  - Audio out
  - Std. Serial
  - USB
  - Video out
- Power
  - Ac Adapter
  - Alkaline and rechargeable batteries
- Additional Lenses
- Scripting
  - Graphic watermark
  - Text watermark
- Time lapse capture
- Tripod mount
- Lightweight, < 1.5 lbs.
- Protective case

APPENDIX 6

GPS System Specifications

Real Time GPS/ NDGPS System Specifications (Configuration 1)

Configuration 1 is the Real Time (RT) Global Positioning System (GPS) / Nationwide Differential Global Positioning System (NDGPS). This GPS System has 10 components which include the Garmin GPSMAP 76 Receiver, the CSI ABX Radio Beacon Receiver, the CSI MGL-3 Dual GPS Beacon External Antenna, Seco GPS Backpack, and a External Battery. These components are commercial of the shelf (COTS) hardware. The other 5 components, the RF Cable, the Extension/Eliminator/Recharging Cable, the Antenna Cable, the Power/Data Communication Cable, and the Male-Male Null Modem Adapter are custom designed to provide power, data, and 4-way communication for the GPS system.

SYSTEM SPECIFICATIONS

RT GPS/NDGPS System Configuration 1	
GPS RECEIVER	
GPS Signal Processing	
Code / Carrier	CA Code
Frequency	L1
Minimum Channels	12 parallel channels
Minimum Acquisition Time	Cold: 45 seconds Warm: 15 seconds Auto Locate: 2 minutes
Minimum Update rate	1 second - continuous
Minimum Built-in Memory	2 MB
Physical Characteristics	
Form factor	Handheld
Maximum Dimensions	7.0"H, 3.0"W , 2.0"D
Maximum Volume	30 cubic inches
Maximum Weight	10 oz.
Drop Specification	3 feet to hard surface - Receiver is fully functional and case integrity maintained
Environ. Sealing	Waterproof to IPX7 Std. Dust proof Ports covered
Operating Temperature	5F to 120F
Storage temperature	0F to 130F
Humidity Tolerance	100%
Predominate hand	Either
Display	
Minimum Dimensions	1.5"W, 2.2"H
Minimum Area	
Type	High Contrast electroluminescent
Graphic	Yes
Minimum No. of Colors	4 levels Gray
Minimum No. of Pixels	1600
Backlight	Yes
Sunlight readable	Yes
Power Supply	
Minimum Internal / duration	16 hours
Minimum External / duration	12 hrs.
Vehicle power cap.	Yes
AC adapter	Yes

GPS RECEIVER con't	
Differential Capability	
Real Time NDGPS	Yes with beacon receiver
Real Time WAAS	Yes
Collecting Positions	
Minimum Waypoints	500
Minimum Routes	20 reversible
Minimum Waypoints per route	30
Minimum Tracks stored	10
Minimum Track points stored	1500
Time stamp waypoints & Tracks	Yes
Positioning Modes	
Averaging	Yes
Auto marking	Yes
Antenna Configurations	
Internal	Yes
External Capability	Yes
Import / Export Formats	
RTCM-SC 104 input	Yes
NMEA 0183 Version 2.x output	Yes
Navigation Aids	
Course Indicator	Yes
Base Map	Yes
Uploadable Maps	Yes
Interfaces	
Serial - RS 232	Yes
Communications / Connections	
PC	Cable - direct
Map - Coordinate Systems	
L/L DMS	Yes
L/L DD	Yes
UTM	Yes
User defined Coordinates & Projections	Yes
Mapping - Datums	
WGS 84	Yes
NAD 27	Yes
NAD 83	Yes
MGRS	Yes
User Definable	Yes
Mapping - Measurements	
Distance between points.	Yes
Bearing between points.	Yes
Area Calculations	Yes
Data Collection Capabilities	
Alfa / Numeric	Waypoints & Track points
Additional Features	
Moving Map Capability	MapSource U.S. Topo CD-Rom
Alarms	Approach and arrival, Off-course, Proximity waypoint,
Start-up test	Yes
Includes	PC interface cable, Owner's Manual Quick Reference Guide

BEACON RECEIVER	
Beacon Receiver Processing	
Minimum Channels	2 Independent
Architecture	Digital
Frequency Range	183.5 - 325.0 kHz
Channel Spacing	500 Hz
MSK Bit Rates	50, 100, and 200 bps
Minimum Acquisition Times	Cold: < 1 minute Warm: , 2 seconds
Demodulation	Minimum Shift Key
Sensitivity	1.5 uV for 6 dB SNR @ 200 bps
Dynamic Range	100dB
Frequency Offset	± 10 Hz
Adjacent Channel Rejection	65dB ± 1 @ fo ± 400 Hz
Physical Characteristics	
Form Factor	Box
Maximum Dimensions	6.0"L, 6.0"W , 3.0"H
Maximum Volume	60 cubic inches
Maximum Weight	1.5 lbs.
Power Connector	2-pin circular locking
Data Connector	DB9-S
Antenna Connector	BNC-S
GPS Connector	TNC-S
Environ. Sealing	Moisture resistant and Dust proof
Oper. Temperature	-30 C to +70 C
Storage Temperature	-40 C to +80 C
Humidity Tolerance	100%
Minimum EMC	EN60945 EN50081-1 EN50082-1
FCC	Part 15, subpart J Class B, Digital Device
Interfaces	
Serial RS-232	Yes
Serial RS-422	Yes
Minimum Selectable Baud Rates	1200, 2400, 4800, 9600
Import / Export Formats	
RTCM SC-104	Yes
NMEA 0183 version 2.x	Automatic & Manual tune Freq. & data rate query Performance & status Baud rate selection Cold start command NMEA command support
Additional Features	
Multiple Antenna Capability	E-field, Whip, H-Field, Loop Antenna, Combination GPS/Beacon Antennas
Firmware upgrades	Easily loaded through serial port
Power consumption	Low power capability to extend battery life
Imput voltages	Wide range to accommodate external battery and vehicle power

External Antenna

Beacon Receiver Processing	
Frequency Range, Beacon	283.5 kHz to 325 kHz
LNA Gain, Beacon	34 dB
Frequency	1.575 GHz (L1)
Physical Characteristics	
Form Factor	External
Maximum Dimensions	6"L, 6"W, 4"H
Maximum Volume	96 cubic inches
Maximum Weight	1lb.
Mounting Thread	1-14-UNS-2B
Connector	TNC-S
Extension Cable	RG-58
Environ. Sealing	Moisture Proof and Dust Proof
Operating Temperate	-30 C to +&0 C
Storage Temperature	-40 C to +80 C
Humidity Tolerance	100%
Power Input	
Input Voltage	4.9 to 13 VDC
Input Current	50 - 60 mA
Additional Features	
Vehicle Capable	Magnetic Mount

GPS Backpack

Physical Characteristics	
Form Factor	Non- frame Backpack
Maximum Dimensions	12" W , 5" D, 22"L
Interior volume	1000 - 1320 cubic inches
Maximum Empty Weight	2.5 lbs.
Shoulder Straps	(2) Adjustable, Padded
Back Pad	Padded mesh
Material	Heavy Duty Cordura Plus Rip Resistant, 1000 denier
Rain Flap	Yes
Safety Reflective Tape	Yes
Interior Compartments	(1) Beacon Receiver (1) External battery
Additional Pockets	Map, Pencil, Manual
Antenna Bar	One, removal, 8" above top of Backpack, with 5/8" survey thread
Additional Features	
Water bladder pocket	Yes
Exterior Markings	USDA Logo

External Battery

Physical Characteristics	
Form Factor	Brick
Power availability	12 v 2.3 Ah
Battery Type	Lead Acid
Rechargeable	From AC/DC Adapter From Vehicle Cigarette Lighter
Environmentally Sealed	Yes
Maximum Dimensions	7.5", 2.5", 1.5"
Maximum Volume	25 cubic inches
Maximum Weight	1.8 lbs.
Cable Type	SPT-1 18 awg x 2C, Zip cord
Cable Attachment	Soldered to leads
Cable length, Battery to Connector	8 15/16 " +/- 1"
Connector	CLP Receptacle with Dust Cap
Additional Features	

Includes	AC/DC Adapter

Configuration 1 - Custom Components

RF Cable

Physical Characteristics	
Cable Purpose	Connect GPS Receiver to Beacon Receiver
CSA/UL Approved	Yes
Cable Type	Polyurethane, Coaxial, 50 ohm, Round
Cable Color	Grey MB 20-882
Cable Length	2.5 Meters
Connectors	MCX to TNC
Connector Colors	MCX = Gold TNC = Metallic Silver Toned
Connector Finish	Over Molded

Extension / Eliminator / Recharging Cable

Physical Characteristics	
Cable purpose	To allow extra length from Backpack to Vehicle cigarette lighter, to provide power to the GPS System without the external battery, and to recharge exterior battery simultaneously while using vehicle power.
CSA/UL Approved	Yes
Cable Type	SPT-1, 18 awg x 2C
Cable Color	Black Jacket
Cable Shape	Zip Cord
Cable Length	J1 CLP Receptacle to P1 CLP 2 meters +/- 10 cm J1 CLP Receptacle to P2 CLP 18" +/- 2"
Cigarette Lighter Plug (CLP) P1 & P2	Red LED 3 amp fuse
Continuity Test each Circuit	C.R. in 1 ohm Max. 1.R. in 5M ohm Mini

Antenna Cable

Physical Characteristics	
Cable Purpose	Connect Beacon Receiver to External GPS/Beacon Antenna
CSA/UL Approved	Yes
Cable Type	Round
Cable Color	Black Jacket
Cable Shape	Round
Cable Length	5 meters +/- 50 cm
Connectors	BNC to TNC
Connector Colors	Both - Metallic Silver Toned
Connector Finish	Over Molded

Power / Data Communication Cable

Physical Characteristics	
Cable Purpose	Provides Power, Data, and Communication
Minimum Communication	Real time 4-way
CSA/UL Approved	Yes
Cable Type	Polyurethane 4 Conductor with foil shield/drain, 24 awg., 19-36 strand
Cable Shape	Round
Cable Color / Length	To GPS Receiver with Garmin 4-pin Connector - Silver, MB 20-746 2.5 Meters +/- 25 cm To Battery with Black CLP = Red, MB 20-443, 18 inches +/- 2.5 cm To Beacon Receiver, XBX Data & DB09 Connector = Green, MB 20-755 18 inches +/- 2.5 cm To Beacon Receiver, XBX power cable with 2-Pin Black Micro Conxall Connector = Green MB-755 18 inches +/- 2.5 cm To other Device, PC1 Data Cable with DB09 Connector = Blue, MB 20-694, 2.5 meters +/- 25 cm To other Device, PC2 Data Cable with DB09 Connector = Sky Blue, MB 20-605, 2.5 meters +/- 25 cm To other Device, PC2 Data Cable with DB09 Connector = Sky Blue, MB 20-605, 2.5 meters +/- 25 cm
Over-molding	Yes with THF Compound
DB9 Connectors	CSA/UL Approved, Polyurethane molded, contoured style with large polyurethane thumbscrews with grip Molded flush with connector
Additional Features	
Cable and Connector Colors	Color coded for easy identification and proper connection

Male - Male Null Modem Adapter

Physical Characteristics	
Purpose	Connection between two DB9 Serial Cables
Connectors	J1-DB9PM J2-DB9PM
Secure fastener	Hex nuts on both sides
Molded	Yes
Color	Black

GPS & External Antenna System Specifications (Configuration 2)

Configuration 2 is a standalone Global Positioning System (GPS) consisting of the Garmin GPSMAP 76 Receiver, the Garmin GA27C External Antenna, and Seco GPS Backpack. All components of the GPS & External Antenna System are commercial of the shelf (COTS) hardware.

SYSTEM SPECIFICATIONS

GPS & External Antenna System Configuration 2	
GPS RECEIVER	
GPS Signal Processing	
Code / Carrier	CA Code
Frequency	L1
Minimum Channels	12 parallel channels
Minimum Acquisition Time	Cold: 45 seconds Warm: 15 seconds Auto Locate: 2 minutes
Minimum Update rate	1 second - continuous
Minimum Built-in Memory	2 MB
Physical Characteristics	
Form factor	Handheld
Maximum Dimensions	7.0"H, 3.0"W , 2.0"D
Maximum Volume	30 cubic inches
Maximum Weight	10 oz.
Drop Specification	3 feet to hard surface - Receiver is fully functional and case integrity maintained
Environ. Sealing	Waterproof to IPX7 Std. Dust proof Ports covered
Operating Temperature	5F to 120F
Storage temperature	0F to 130F
Humidity Tolerance	100%
Predominate hand	Either
Display	
Minimum Dimensions	1.5"W, 2.2"H
Minimum Area	
Type	High Contrast electroluminescent
Graphic	Yes
Minimum No. of Colors	4 levels Gray
Minimum No. of Pixels	1600
Backlight	Yes
Sunlight readable	Yes

GPS RECEIVER con't.	
Power Supply	
Minimum Internal / duration	16 hours
Minimum External / duration	12 hrs.
Vehicle power cap.	Yes
AC adapter	Yes
Differential Capability	
Real Time NDGPS	Yes with beacon receiver
Real Time WAAS	Yes
Collecting Positions	
Minimum Waypoints	500
Minimum Routes	20 reversible
Minimum Waypoints per route	30
Minimum Tracks stored	10
Minimum Track points stored	1500
Time stamp waypoints & Tracks	Yes
Positioning Modes	
Averaging	Yes
Auto marking	Yes
Antenna Configurations	
Internal	Yes
External Capability	Yes
Import / Export Formats	
RTCM-SC 104 input	Yes
NMEA 0183 Version 2.x output	Yes
Navigation Aids	
Course Indicator	Yes
Base Map	Yes
Uploadable Maps	Yes
Interfaces	
Serial - RS 232	Yes
Communications / Connections	
PC	Cable - direct
Map - Coordinate Systems	
L/L DMS	Yes
L/L DD	Yes
UTM	Yes
User defined Coordinates & Projections	Yes
Mapping - Datums	
WGS 84	Yes
NAD 27	Yes
NAD 83	Yes
MGRS	Yes
User Definable	Yes
Mapping - Measurements	
Distance between points.	Yes
Bearing between points.	Yes
Area Calculations	Yes
Data Collection Capabilities	
Alfa / Numeric	Waypoints & Track points
Additional Features	
Alarms	Approach and arrival, Off-course, Proximity waypoint,
Start-up test	Yes
Includes	PC interface cable, Owner's Manual Quick Reference Guide

External Antenna

Beacon Receiver Processing	
Frequency Band	1575.42 MHz +/- 1.023MHz
LNA Gain	15 dB min. 20dB max.
Selectivity +/- 40 MHz +/- 100 MHz	20 dB max. 40 dB max.
Antenna Gain - No Ground Plane	90 degrees 0 dBi min. 20 degrees -7 dBi min.
Antenna Gain - Ground Plane	90 degrees 2.5 dBi min. 20 degrees -5dBi min.
Polarization	RHCP
Cross Polarization - No Ground Plane	90 degrees -6dB min. 20 degrees -3 dB min.
Cross Polarization - No Ground Plane	90 degrees -8 dB min. 20 degrees -3 dB min.
Physical Characteristics	
Form Factor	External
Maximum Dimensions	3" x 2" x 3/4"
Maximum Volume	3.5 cubic inches
Maximum Weight	2.4 oz.
Connector	MCX
Cable	RG174
Minimum Cable length	8 ft.
Environ. Sealing	Moisture Proof and Dust Proof
Minimum Operating Temperate	-30 C to +&0 C
Minimum Storage Temperature	-40 C to +85 C
Humidity Tolerance	100%
Current Consumption 5 VDC 3 VDC	10 mA Max. 7 mA max.
Operating Voltage	2.0 vDc min. to 8.0 vDC max.
Additional Features	
Mounting Base	Magnetic

GPS Backpack

Physical Characteristics	
Form Factor	Non- frame Backpack
Maximum Dimensions	12" W , 5" D, 22"L
Interior volume	1000 - 1320 cubic inches
Maximum Empty Weight	2.5 lbs.
Shoulder Straps	(2) Adjustable, Padded
Back Pad	Padded mesh
Material	Heavy Duty Cordura Plus Rip Resistant, 1000 denier
Rain Flap	Yes
Safety Reflective Tape	Yes
Interior Compartments	Beacon Receiver Pocket (1) External Battery Pocket (1)
Additional Pockets	Map, Pencil, Manual
Antenna Bar	One, removal, 8" above top of Backpack, with 5/8" survey thread
Additional Features	
Water bladder pocket	Yes
Exterior Markings	USDA Logo

APPENDIX 7

Digital Camera Specifications

SYSTEM SPECIFICATIONS

Digital Camera

Purpose	To acquire digital images
Form Factor	Handheld
Maximum Dimensions	6.0W in, 3.5H in, 3Din
Maximum Volume	36 square inches
Maximum Weight (w/o batteries)	12 oz
Display	Optical Viewfinder LCD, minimal 1.8" Diag. Screen
Optics	
Minimum Sensor	2.1 megapixel
Minimum Color Depth	24 bit
Color	Full color, Black and White
Minimum Selectable Resolutions	800 x 600, 1600 x 1200
Minimum Optical Zoom	2X
Minimum Digital Zoom	3X
Minimum Shutter Speed Range	1/1000 to 4 seconds
Minimum Focus Range	Normal = 0.5 meters to infinity Macro = 0.25 meters to 0.5 meters
Sensitivity	Auto or fixed (ISO 100 or 200)
Flash	
Built-in Internal Flash	Yes
Flash Modes	Auto, Red-eye Reduction, Off
Power	
Internal Battery Power	Lithium AA batteries or Ni-MH Rechargeables
AC adapter	Yes
Storage	
Images stored	JPEG(EXIF)
Minimum Compact Flash Memory	16 MB
Connectivity	
USB	Yes
Audio/Video out	Yes
Additional Features	
Imaging Software	Yes
Power saving features	Yes
Attach Audio to Images	Yes
Camera Includes	
Universal Serial Cable	Yes
Audio / Video Cable	Yes
Compact Flash Card	16 MB
Manual	Yes
Camera Case	Yes

Compact Flash Card Reader

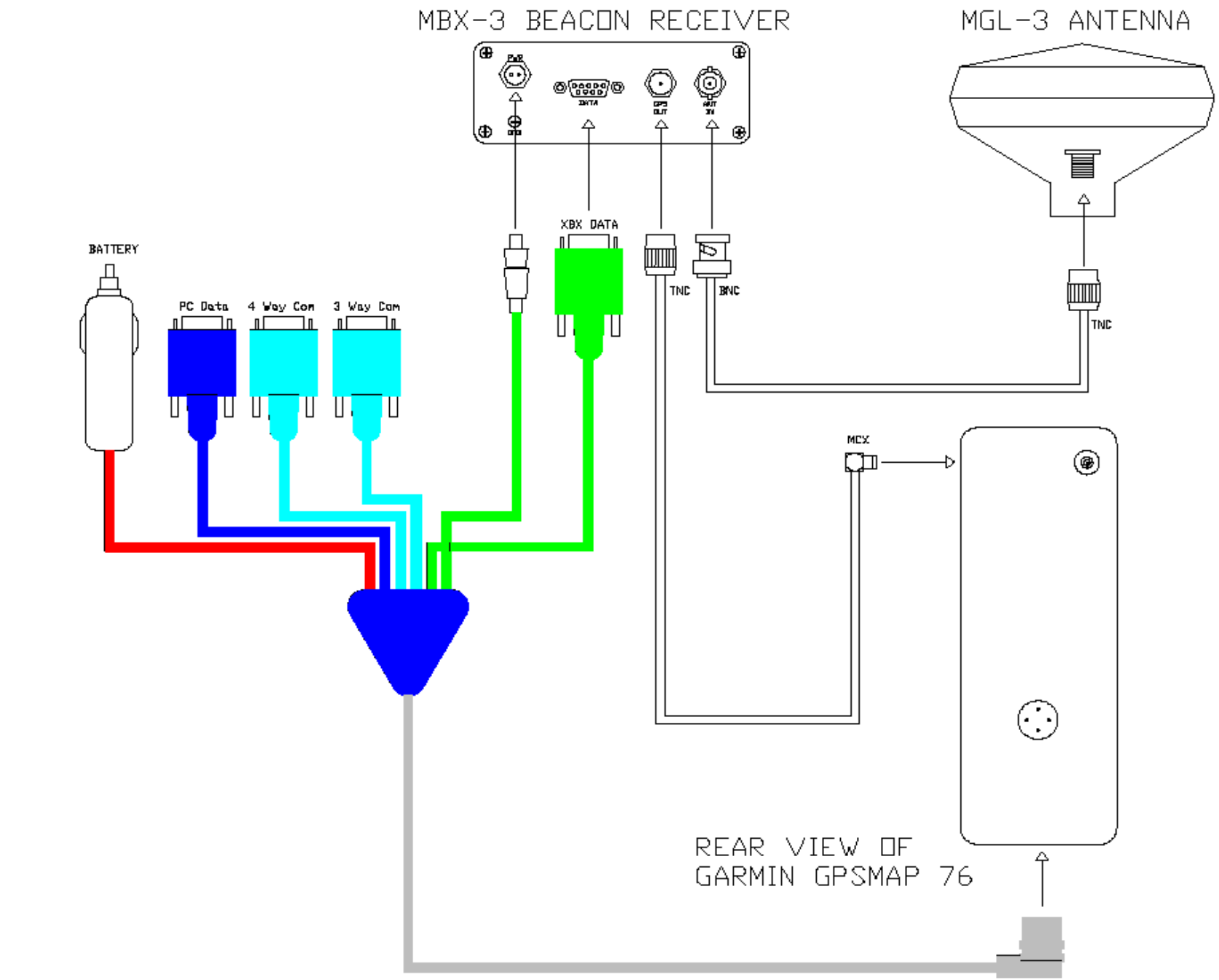
Specifications	
Form Factor	External
Maximum Weight	8 oz.
Type of Media	CompactFlash
Operating System	Microsoft Windows NT
Interface	Parallel

TO BE ADDED

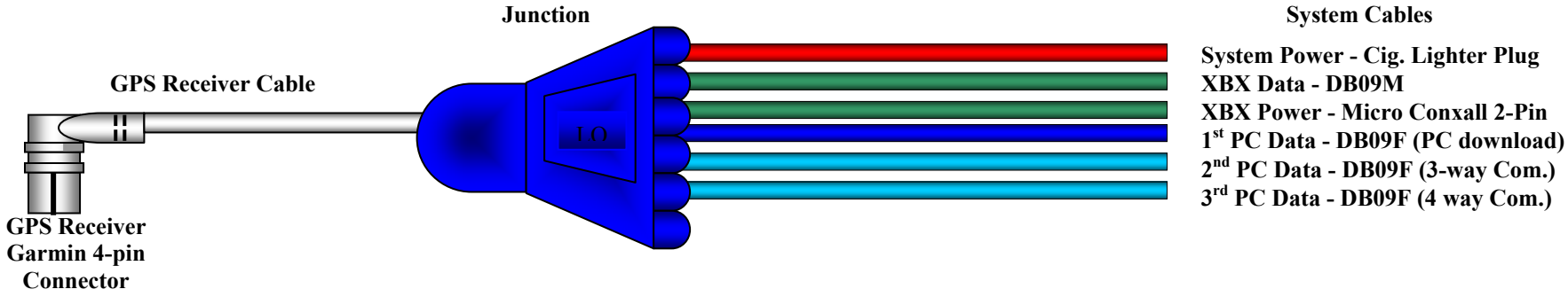
GPS & Digital Camera Integration Software

APPENDIX 8

Custom Cable Diagrams


MBX-3 BEACON RECEIVER
MGL-3 ANTENNA
BATTERY
PC Data
4 Way Com
3 Way Com
XBX DATA
TNC
BNC
TNC
MCX
REAR VIEW OF
GARMIN GPSMAP 76
NOT TO SCALE

POWER / DATA COMMUNICATION CABLE



Cable	Cable Type	Cable Length	Cable Color	Cable Connector
GPS Receiver Cable	Polyurethane 4 Conductor with foil shield/drain, 24awg., 19-36 strand, Round	2.5 Meters +/- 25cm	Silver MB 20-746	Garmin 4-pin
System Power Cable to Battery		18" +/- 2.5 cm	Red, MB 20-443	Cigarette Lighter Plug
XBX data Cable to Beacon Receiver		18" +/- 2.5 cm	Green MB 20-755	DB09M
XBX Power Cable to Beacon Receiver		18" +/- 2.5cm	Green MB 20-755	2-pin Black Micro Conxall
1st PC Data cable (notebook, laptop)		2.5 meters +/- 25 cm	Blue MB 20-694	DB09F
2nd PC Data Cable (HPC Camera)		2.5 meters +/- 25 cm	Sky Blue MB 20-605	DB09F
3rd PC Data cable (HPC Camera)		2.5 meters +/- 25 cm	Sky Blue MB 20-605	DB09F